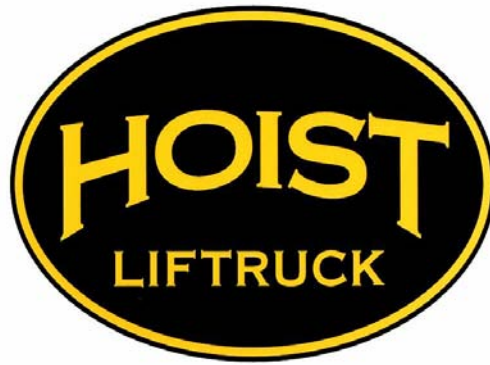


Introduction

This Service Manual was designed to help the Qualified Service Technician maintain and service **Hoist Industrial Trucks**. Inside you will find detailed descriptions of components and the procedures to repair, replace and service these items.



We hope this Manual assists you with any Repairs or Maintenance needed. If you can not locate the procedure needed or have any additional questions please contact us.

Hoist Liftruck, Mfg., Inc.

Service Department

Technical Assistance 1-800-367-5600

Monday through Friday 8:00am – 5:00pm Central Time

Maintenance And Rebuild Practices

Provisions for Maintenance

Powered industrial trucks may become hazardous if maintenance is neglected or repairs, rebuilds or adjustments are performed contrary to manufacture's design criteria. Therefore, maintenance facilities (on or off premises), trained personnel and explicit procedures shall be provided.

Parts manuals and maintenance manuals may be obtained from the truck manufacturer. In unusual cases not covered by the manuals, consult the truck manufacturer.

Maintenance and inspection of all powered industrial trucks shall be performed in accordance with the manufacturer and user's recommendations and the following practices:

1. A scheduled planned maintenance, lubrication and inspection system shall be followed.
2. Only trained and authorized personnel shall be permitted to maintain, repair, adjust and inspect industrial trucks, in accordance with manufacturers specification.

Caution:

Before starting inspection and repairs of trucks:

1. Raise drive wheels free of floor or disconnect battery and use blocks or other positive truck positioning devices.
2. Block load engaging means, inner masts, or chassis before working on them.
3. Before disconnecting any part of the engine fuel system of gasoline-powered trucks with gravity feed fuel systems. Take precautions to eliminate any possibility of unintentional fuel escape.
4. Before disconnecting any part of the engine fuel system of LP gas powered trucks, close LP tank valve and run engine until fuel system is depleted and engine stops. If the engine will not run, close LP truck valve and vent fuel slowly in a non-hazardous area.
5. On battery powered trucks, disconnect battery before working on the electrical system.
6. The charger connector shall be plugged only into the battery connector and never into the truck connector.
7. If the truck has a hydraulic accumulator installed in the hydraulic steering circuit, discharge the pressure in the hydraulic system by moving the steer handle or wheel back and forth until any stored oil pressure is depleted. This is essential to prevent any unintentional movement of the steering mechanism when the power to truck is disconnected.

Brakes, steering mechanism, control mechanism, warning devices, lights, governors, lift overload devices, guards and safety devices lift and tilt mechanisms, articulating axle stops and frame members shall be carefully and regularly inspected and maintained in a safe operating condition.

Special trucks or devices designed and approved for hazardous area operation shall receive special attention to ensure that maintenance preserves the original, approved safe operating features.

Safety Precautions and Truck Maintenance Cautions

The following “**precautions**” should be followed when working on a forklift.

- Always wear eye protection.
- Do not smoke while working on the vehicle.
- Always turn the key switch to the OFF position, unless a procedure requires the key switch to be in the ON position.
- Set the parking brake. Place chocks in the front and rear of the tires to prevent vehicle movement.
- Always use approved safety stands or blocks, when having to work under the vehicle.
- Always discharge capacitors prior to working with electrical components, to prevent dangerous electrical shock.
- Always service industrial truck batteries in a well ventilated area, to prevent danger of explosion for accumulating gases.
- Avoid contact with battery acid the corrosive acid can cause injury.

The following is a list of lift truck maintenance “**cautions**” for trucks equipped with solid-state control panels.

CAUTION WELDING ON LIFT TRUCKS

- Make sure the vehicle has no grounds.
- Disconnect the truck battery.
- Protect electrical wiring and components from weld spatter with a shield.
- Ventilate the battery or remove from the vehicle.

Note: Damage to the wiring and electrical components can result if the directions above are not followed.

CAUTION DO NOT STEAM-CLEAN

Note: Steam cleaning a solid-state lift truck creates excessive moisture that will interfere with the proper operation of the solid-state components.

The solid-state controls should be cleaned at regular intervals. Blowing dirt off with an air hose “207 kpa (30psi) max.” periodically. This will help eliminate any serious cleaning problems.

To do a thorough cleaning with a liquid follow the procedures below.

- Disconnect the battery from the vehicle.
- Use only water and mild detergent “dish washing detergent”
- Air-dry the controls thoroughly before connecting the battery and putting the vehicle back into service.

CAUTION CHECK BATTERY POLARITY

Note: The battery polarity must be correct or the vehicle will not operate.

CAUTION USE TRUCK BATTERY ONLY

Do not use a motor generator unit or a battery charger to check or move a solid state controlled vehicle. Doing so can cause serious damage to the electrical components.

TORQUING OF FASTENERS

Objective: Recognize the importance of the proper torquing of fasteners and the required torquing procedures.

Fastener fatigue failure accounts for the majority of all fastener problems. Fatigue breaks are caused by insufficient tightening and the lack of proper preload or clamping force. This results in movement between the parts of the assembly and bending back and forth or cyclic stressing of the fastener. Eventually, cracks will progress to the point where the fastener can no longer support its designed load. At this point the fastener fails with varying consequences.

TORQUING PROCEDURES

For the nut to properly load the bolt and prevent premature failure, a designated amount of torque must be applied. Proper torque reduces the possibility of the fastener loosening while in service. The correct torque to apply when you are tightening an assembly is based on many variables. The fastener is subjected to two stresses when it is tightened. These stresses are torsion and tension. Tension is the desired stress, while torsion is the undesirable stress caused by friction. A large percentage of applied torque is used to overcome this friction, so that only tension remains after tightening. Proper tension reduces the possibility of fluid leaks.

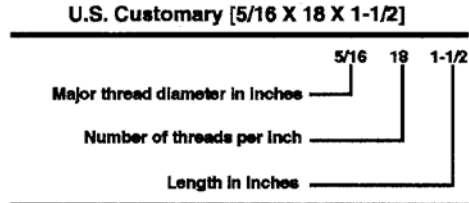
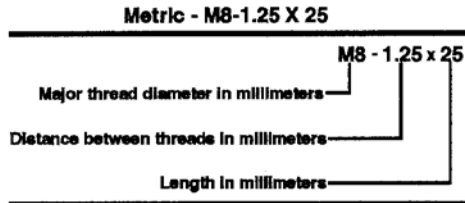
Capscrew Markings and Torque Values

⚠ CAUTION ⚠

When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:



NOTES:

1. **Always** use the torque values listed in the following tables when specific torque values are **not** available.
2. Do **not** use the torque values in place of those specified in other sections of this manual.
3. The torque values in the table are based on the use of lubricated threads.
4. When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

HOIST TORQUE CHART

class 8.8 (standard)		
	dry treads	lubricated treads
DIA.	[Ft-lbs]	[Ft-lbs]
M4	2	1
M5	5	3
M6	8	5
M7	13	8
M8	19	11
M10	37	22
M12	66	39
M14	104	62
M16	162	98
M18	230	138
M20	325	196
M24	565	340
M30	1119	672
M36	1955	1173

class 10.9		
	dry treads	lubricated treads
DIA.	[Ft-lbs]	[Ft-lbs]
M4	3	2
M5	7	4
M6	11	7
M7	19	11
M8	27	16
M10	53	32
M12	94	56
M14	148	90
M16	232	140
M18	315	190
M20	450	270
M24	780	470
M30	1548	929
M36	2705	1623

class 12.9		
	dry treads	lubricated treads
DIA.	[Ft-lbs]	[Ft-lbs]
M4	4	2
M5	8	5
M6	14	8
M7	23	14
M8	34	20
M10	66	40
M12	116	70
M14	184	110
M16	290	172
M18	395	238
M20	560	335
M24	972	585
M30	1930	1158
M36	3372	2023

lock nuts			
	class 8.8	class10.9	class12.9
DIA.	[Ft-lbs]	[Ft-lbs]	[Ft-lbs]
M4	1	1	2
M5	2	3	4
M6	4	5	6
M7	6	8	10
M8	9	12	15
M10	17	24	30
M12	29	42	52
M14	47	66	84
M16	74	104	130
M18	104	144	178
M20	146	202	255
M24	255	350	440
M30	505	702	864
M36	882	1224	1512

Capscrew Markings and Torque Values - Metric

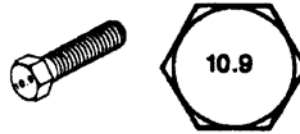
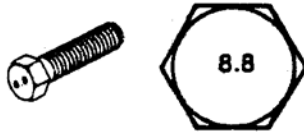
Commercial Steel Class

8.8

10.9

12.9

Capscrew Head Markings



Body Size Diameter mm	Torque				Torque				Torque			
	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

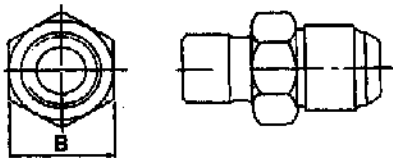
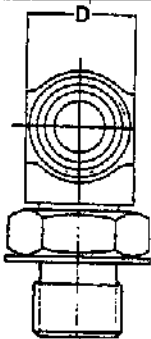
Pipe Plug Torque Values

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
In	In	N•m	ft-lb	N•m	ft-lb
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

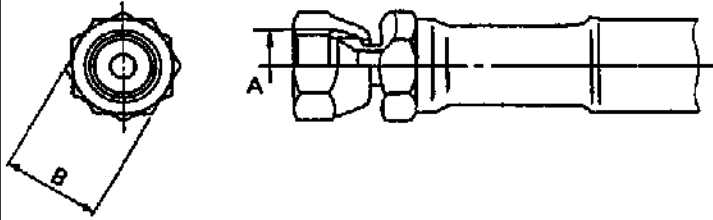
STANDARD TIGHTENING TORQUE FOR PIPE JOINTS

STANDARD TIGHTENING TORQUE FOR PIPE JOINTS

Elbows, Nipples and Unions






Width across flats B (mm)	22	30	36
Width D (mm)	19	22	30
Tightening torque (kgm)	3 — 4	8 — 10.5	12 — 16.5
Port size (inch)	3/4-16UNF	13/16-12UNF	15/16-12UNF
Tightening torque (kgm)	7 — 7.5	12 — 16.5	11 — 15
<div><div>Union</div></div> <div><div>Elbow</div></div>			

High pressure Rubber Hoses, Pipes and Sleeve Nuts

Width across flats B (mm)	19	24	27	32	36
Bore A (mm)	14	18	22	24	30
Tightening torque (kgm)	2 — 3	3 — 7	6 — 10	11 — 17	15 — 21
					






STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS

SPECIFICATION
SECTION

FASTENER (Fine or Coarse Thread)	 Cap Screw	 Cap Screw	 Cap Screw	 Cap Screw	 Cap Screw
Grade Designa- tion	S.A.E. 2 A.S.T.M. A-307	S.A.E. 3	A.S.T.M. A-449 S.A.E. 5	A.S.T.M. 354BB	A.S.T.M. A-325*
Tensile Strength Minimum	64,000 P.S.I.	100,000 P.S.I.	105,000 P.S.I.		
Material	Low Carbon Steel	Medium Carbon Steel	Medium Carbon Steel or Low Alloy Heat Treated		
ELWELL- PARKER Standard Part No.	6000-2 6151-2				
Screw Shank Size or Diameter	Torque figures in foot pounds unless otherwise noted				
1/4	6	9	9		
5/16	11	17	18		
3/8	19	30	31		
7/16	30	47	50		
1/2	45	69	75	100	
9/16	66	103	110		
5/8	93	145	150	200	
3/4	150	234	250	355	
7/8	202	372	378	525	
1	300	551	583	790	
1-1/8	474	872	782	1060	
1-1/4	659	1211	1097	1495	
1-3/8	884	1624	1461	1960	
1-1/2	1057	1943	1748	2600	
1-5/8	1448	2660	2392	*Torque specifica- tions are	
1-3/4	1884	3463	3114		






STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

FASTENER (Fine or Coarse Thread)	Cap Screw S.A.E. 2 A.S.T.M. A-307 (cont.)	Cap Screw S.A.E. 3 (cont.)	Cap Screw A.S.T.M. A-449 S.A.E. 5 (cont.)	Cap Screw A.S.T.M. 354BB (cont.)	Cap Screw A.S.T.M. A-325* (cont.)
1-7/8	2336	4659	4191		for perma- nent fas- tenings on steel structures
2	2721	5427	4504		
2-1/4	3417	7226	6497		
2-1/2	4380	8049	7144		
2-3/4	7319	13450	12092		
3	9455	17548	15775		

FASTENER (Fine or Coarse Thread)	 Cap Screw	 Cap Screw	 Cap Screw	 Cap Screw	 Cap Screw
Grade Designa- tion	A.S.T.M. A-354-BC	S.A.E. 6	S.A.E. 7	S.A.E. 8	A-354-BD A490*
Tensile Strength Minimum	125,000 P.S.I.	133,000 P.S.I.		150,000 P.S.I.	150,000 P.S.I.
Material	Low Alloy or Med. Carbon Quenched Tempered	Med. Carbon Steel Quenched Tempered	Med. Carbon Alloy Quenched Tempered Roll Thrd.	Med. Carbon Alloy Quenched Tempered	Med. Carbon Alloy Quenched Tempered
ELWELL- PARKER Standard Part No.					
Screw Shank Size or Diameter	Torque figures in foot pounds unless otherwise noted				
1/4	11	12.5		13	
5/16	20	24		28	
3/8	34	43		46	55
7/16	54	69		75	90
1/2	81	106		115	138
9/16	119	150		165	198
5/8	167	209		225	270

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC










FASTENER (Fine or Coarse Thread)	Cap Screw A.S.T.M. A-354-BC (cont.)	Cap Screw S.A.E. 6 (cont.)	Cap Screw S.A.E. 7 (cont.)	Cap Screw S.A.E. 8 (cont.)	Cap Screw A-354-BD A490* (cont.)
3/4	269	350		370	444
7/8	427	550		591	709
1	644	825		893	1071
1-1/8	1002	1304		1410	1692
1-1/4	1392	1815		1964	2360
1-3/8	1868	2434		2633	3159
1-1/2	2234	2913		3150	3780
1-5/8	3059	3985		4311	5173
1-3/4	3982	5189		5614	6736
1-7/8	5457	6980		7550	*Specifica- tions are for perma- nent steel structures
2	5749	7491		8104	
2-1/4	8308	10825		11710	
2-1/2	9255	14983		16208	
2-3/4	15465	20151		22440	
3	20176	26286		28436	

FASTENER (Fine or Coarse Thread)	 Socket Cap Screw	 Cap Screw	 Cap Screw	 Cap Screw	 Stud
Grade Designa- tion	Soc. Hd. Cap Screw also N.A.S. Aircraft Std.	N.A.S. 144 Aircraft Std. MS 20000 MIL Std.	N.A.S. 624 National Aircraft Std. Steel	Aircraft No Number Assigned Steel	Studs (See Explana- tion) Steel
Tensile Strength Minimum	160,000 P.S.I.		180,000 P.S.I.	220,000 P.S.I.	
Material	High Carbon Alloy Quenched Tempered		High Carbon Alloy Quenched Tempered	High Carbon Alloy Quenched Tempered	
ELWELL- PARKER Standard Part No.					

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC










FASTENER (Fine or Coarse Thread)	Socket Hd. Cap Screw also N.A.S. Aircraft Std. (cont.)	Cap Screw N.A.S. 144 Aircraft Std. MS 20000 MIL Std. (cont.)	Cap Screw N.A.S. 624 Natl. Air- craft Std. (cont.)	Cap Screw Aircraft No Number Assigned (cont.)	Stud (See Explana- tion) (cont.)
Screw or Stud Shank Size or Diameter	Torque figures are in foot pounds unless otherwise noted				
1/4	14		16	19	Studs may be ordered per S.A.E. grade codings 2, 5 and 8. Use cap screw fig- ures when grade is known.
5/16	30		34	41	
3/8	50		56	69	
7/16	81		91	111	
1/2	121		136	166	
9/16	176		198	232	
5/8	240		270	330	
3/4	395		444	534	
7/8	629		708	865	
1	964		1085	1326	
1-1/8	1523		1713	2094	
1-1/4	2120		2385	2916	
1-3/8	2843		3198	4009	
1-1/2	3402		3827	4678	
1-5/8	4655		5237	6401	
1-3/4	6063		6821	8337	
1-7/8	8154		9173	11212	
2	8751		9845	11685	
2-1/4	12645		14226	17387	
2-1/2	17503		19691	24067	
2-3/4	23541		26484	32369	
3	30709		34548	42225	

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

FASTENER (Fine or Coarse Thread)	 Set Screw	 Thd. Ctg. Screw	 Tpg. Screw	 Cap Screw	 Mach. Screw	 Cap Screw	 Mach. Screw	 Cap Screw	 Mach. Screw
Grade Designa- tion	Socket Set Scr. Steel	Metal		Stainless Steel		Stainless Steel		Yellow Brass	
Tensile Strength Minimum	212,000 to 225,000 P.S.I.							60,000	
Material	High Car- bon Alloy Quenched Tempered			18-8		316 Series		Cu 63 Zn 37	
ELWELL- PARKER Standard Part No.	6185-2 6186-2 6188-2 6302-2	6222-2 6223-2 6224-2 6225-2 6226-2 6229-2 6230-2 6231-2 6232-2 6233-2							
Screw Shank Size or Diameter	Torque figures are in foot pounds unless otherwise noted								
2		Tapping screws vary widely in both design and use. Torque re- quirements are depend- ent on the material to be fastened, the screw strength and other factors. A rule of thumb for determining production torque is as follows: Using the screw manu- facturers	2.5 in. lbs.	2.6 in. lbs.	2 in. lbs.				
3			4 in. lbs.	4 in. lbs.	3.2 in. lbs.				
4			5.2 in. lbs.	5.5 in. lbs.	4.3 in. lbs.				
5			8 in. lbs.	8 in. lbs.	6.3 in. lbs.				
6	9 in. lbs.		9.6 in. lbs.	10 in. lbs.	8 in. lbs.				
8	16 in. lbs.		20 in. lbs.	21 in. lbs.	16 in. lbs.				
10	30 in. lbs.		23 in. lbs.	24 in. lbs.	19 in. lbs.				
1/4	70 in. lbs.		75 in. lbs.	79 in. lbs.	62 in. lbs.				

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

FASTENER (Fine or Coarse Thread)	Socket Set Screw Steel (cont.)	Thd. Ctg. Tpg. Screw Screw Metal (cont.)	Cap Mach. Screw Screw Stainless Steel (cont.)	Cap Mach. Screw Screw Stainless Steel (cont.)	Cap Mach. Screw Screw Yellow Brass (cont.)
5/16	140 in. lbs.	recommended screw and hole size for the ap- plication, take note of the torque nec- essary to strip or otherwise cause fail- ure of the joint. (Test 10 or more). Ap- plication torque is 60 to 70% of lowest failing torque for any of the test group.	132 in. lbs.	138 in. lbs.	107 in. lbs.
3/8	18 ft. lbs.		20 ft. lbs.	21 ft. lbs.	16 ft. lbs.
7/16	29		31	33	26
1/2	43		43	45	35
9/16	63		57	59	47
5/8	100		92	97	76
3/4	146		124	130	102
7/8			194	202	158
1			259	271	212
1-1/8			390	408	318
1-1/4			480	504	394
1-3/8					
1-1/2			703	732	575

FASTENER (Fine or Coarse Thread)	  Cap Mach. Screw Screw	  Cap Mach. Screw Screw	  Sems Mach. Screw	  Mach. Screw	 Sems
Grade Designa- tion	Silicon Bronze (Low) Type "B"	Aluminum 2024-T4	Steel	Heat Treated Steel (Used at times)	Heat Treated Steel
Tensile Strength Minimum	70,000	55,000	55,000	Above 55,000	120,000
Material	Cu 96 Min. St 1.5-2 Zn 1-5 Min.	Cu 3.8-4.9 1.2-1.8 Mn .3-.9 Al Balance	1010 Etc. Not Heat Treated		1018 1022
ELWELL- PARKER Standard Part No.			6009-2		

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

FASTENER (Fine or Coarse Thread)	Cap Screw Silicon Bronze (Low) Type "B" (cont.)	Mach. Screw Aluminum 2024-T4 (cont.)	Mach. Screw Steel (cont.)	Mach. Screw Heat Treated Steel (Used at times) (cont.)	Sems Heat Treated Steel (cont.)
Screw Shank Size or Diameter	Torque figures are in foot pounds unless otherwise noted				
2	2.3 in. lbs.	1.4 in. lbs.	2.5 in. lbs.	Divide the minimum tensile strength of the material constituting the finished machine screw by the factor 55,000. Multiply this figure obtained by the torque value in the applicable screw no. column of the screw immediately preceding this one.	4 in. lbs.
3	3.6 in. lbs.	2.1 in. lbs.	3.7 in. lbs.		5 in. lbs.
4	4.8 in. lbs.	2.9 in. lbs.	6 in. lbs.		7 in. lbs.
5	7.1 in. lbs.	4.2 in. lbs.	8 in. lbs.		10 in. lbs.
6	9 in. lbs.	5.3 in. lbs.	11 in. lbs.		14 in. lbs.
8	18 in. lbs.	11 in. lbs.	20 in. lbs.		25 in. lbs.
10	21 in. lbs.	14 in. lbs.	32 in. lbs.		35 in. lbs.
1/4	69 in. lbs.	45 in. lbs.	75 in. lbs.		85 in. lbs.
5/16	123 in. lbs.	80 in. lbs.	140 in. lbs.		195 in. lbs.
3/8	18 ft. lbs.	12 ft. lbs.			325 in. lbs.
7/16	29	19			
1/2	40	26			
9/16	52	34			
5/8	86	60			
3/4	115	80			
7/8	178	125			
1	240	166			
1-1/8	361	251			
1-1/4	447	308			
1-3/8					
1-1/2	651	450			

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

SUGGESTED MAXIMUM TORQUE VALUES
FOR FASTENERS OF DIFFERENT MATERIALS

ELWELL- PARKER Standard Part No.			6010-2 6205-2 6206-2			
BOLT SIZE	Low Carbon Steel	18-8 St.St.	Brass	Silicon Bronze	Aluminum 24ST-4	316 St.St.
	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.
2-56	2.2	2.5	2.0	2.3	1.4	2.6
2-64	2.7	3.0	2.5	2.8	1.7	3.2
3-48	3.5	3.9	3.2	3.6	2.1	4.0
3-56	4.0	4.4	3.6	4.1	2.4	4.6
4-40	4.7	5.2	4.3	4.8	2.9	5.5
4-48	5.9	6.6	5.4	6.1	3.6	6.9
5-40	6.9	7.7	6.3	7.1	4.2	8.1
5-44	8.5	9.4	7.7	8.7	5.1	9.8
6-32	8.7	9.6	7.9	8.9	5.3	10.1
6-40	10.9	12.1	9.9	11.2	6.6	12.7
8-32	17.8	19.8	16.2	18.4	10.8	20.7
8-36	19.8	22.0	18.0	20.4	12.0	23.0
10-24	20.8	22.8	18.6	21.2	13.8	23.8
10-32	29.7	31.7	25.9	29.3	19.2	33.1
1/4-20	65.0	75.2	61.5	68.8	45.6	78.8
1/4-28	90.0	94.0	77.0	87.0	57.0	99.0
5/16-18	129	132	107	123	80	138
5/16-24	139	142	116	131	86	147
3/8-16	212	236	192	219	143	247
3/8-24	232	259	212	240	157	271
7/16-14	338	376	317	349	228	393
7/16-20	361	400	327	371	242	418
1/2-13	465	517	422	480	313	542
1/2-20	487	541	443	502	328	565
9/16-12	613	682	558	632	413	713
9/16-18	668	752	615	697	456	787
5/8-11	1000	1110	907	1030	715	1160
5/8-18	1140	1244	1016	1154	798	1301
3/4-10	1259	1530	1249	1416	980	1582
3/4-16	1230	1490	1220	1382	958	1558

STANDARD TORQUE VALUES FOR METAL INDUSTRIAL FASTENERS—SPEC

TORQUE VALUES FOR FASTENERS OF DIFFERENT MATERIALS (cont.)						
BOLT SIZE	Low Carbon Steel (cont.)	18-8 St.St. (cont.)	Brass (cont.)	Silicon Bronze (cont.)	Aluminum 24ST-4 (cont.)	316 St.St. (cont.)
	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.
7/8-9	1919	2328	1905	2140	1495	2430
7/8-14	1911	2318	1895	2130	1490	2420
1"-8	2832	3440	2815	3185	2205	3595
1"-14	2562	3110	2545	2885	1995	3250
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.
1-1/8-7	340	413	337	383	265	432
1-1/8-12	322	390	318	361	251	408
1-1/4-7	432	523	423	485	336	546
1-1/4-12	396	480	394	447	308	504
1-1/2-6	732	888	727	822	570	930
1-1/2-12	579	703	575	651	450	732

Fraction, Decimal, Millimeter Conversions

Fraction	inch	mm	Fraction	inch	mm
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.669
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638
21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

Conversion Factor: 1 inch = 25.4 mm

[illegible]

Drain and refill transmission. Clean transmission oil intake filter screen (use new gasket)						CG				CG
Transmission filter element. Clean filter housing (use new gaskets)			CG	CG	CG	CG	CG	CG	CG	CG
STEER AXLE ** Torque Studs after first 10 Hours of Service, weekly thereafter										
Lubricate all grease fittings			GR	GR	GR	GR	GR	GR	GR	GR
Inspect and repack hub bearings						GR				GR
Adjust wheel bearings						A				A
Check mounting bolts			X	X	X	X	X	X	X	X
DRIVE AXLE ** Torque Studs after first 10 Hours of Service, weekly thereafter										
Differential and planetary hubs - maintain oil level			X	X	X	X	X	X	X	X
Differential and planetary hubs - change oil										CG
Inspect brake linings (drum and shoe type)										X
Adjust slack adjusters			A	A	A	A	A	A	A	A
Grease s-cams and slack adjusters			GR	GR	GR	GR	GR	GR	GR	GR
Check mounting bolts			X	X	X	X	X	X	X	X
CHASSIS										
Lubricate remaining grease fittings and linkages			GR	GR	GR	GR	GR	GR	GR	GR
Check tires, valve stems and caps, wheels, lugs. And tire pressure			X	X	X	X	X	X	X	X
HYDRAULIC SYSTEM										
Maintain hydraulic level in reservior	X	X	X	X	X	X	X	X	X	X
Check hoses and piping for crackes, chafing, leaking, and loose fittings			X	X	X	X	X	X	X	X
Drain, clean instde tank, and refill system										CG
Replace hydraulic tank breather			CG	CG	CG	CG	CG	CG	CG	CG
Suction strainers										CG
Return line filter **Change after the first 50 hours, then follow schedule			CG	CG	CG	CG	CG	CG	CG	CG
Control valve - check for proper operation			X	X	X	X	X	X	X	X
Control valve - check for leaks			X	X	X	X	X	X	X	X
Hydraulic cylinders - check for leaks and damage			X	X	X	X	X	X	X	X
Accumulators - check nitrogen precharge			X	X	X	X	X	X	X	X
MAST AND ATTACHMENT										
Lubricate mast hinges			GR	GR	GR	GR	GR	GR	GR	GR
Lubricate all mast and attachment grease points including, main and side rollers, slides, carriage rollers, and all other grease fittings on mast.		GR	GR	GR	GR	GR	GR	GR	GR	GR
Check all rollers for smooth motion			X	X	X	X	X	X	X	X
Check lift chains for rust, streching, and cracking			X	X	X	X	X	X	X	X
Check lift chains for proper adjustment			A	A	A	A	A	A	A	A
check chain anchors and pins for wear			X	X	X	X	X	X	X	X

[illegible]

F-Series Chassis

Chassis

Contents of this section

This section describes the repair procedures for the chassis and connected parts.

Chassis

The FKS chassis is a one-piece weldment and is designed for the utmost rigidity and reliability. The chassis incorporates the front axle mount, overhead guard mounting, steer axle mounting, engine and transmission mounts, integral hydraulic and fuel tanks.

WARNING

The removal of the following assemblies will cause large changes in the center of gravity: mast, drive axle, engine and transmission, and the counterweight.

The lift truck must be put on blocks for some types of maintenance and repair. When the lift truck is put on blocks put additional blocks in the following positions to maintain stability:

- 1. Before removing the mast and drive axle, put blocks under the counterweight so that the lift truck cannot fall backward.**
- 2. Before removing the counterweight, put blocks under the mast assembly so that the lift truck cannot fall forward.**

The surface must be solid, even, and level when the lift truck is put on blocks. Make sure that any blocks used to support the lift truck are solid, one piece units.

NOTE: Some lift trucks have lifting eyes. These lift points can be used to raise the lift truck so that blocks can be installed.

How To Raise The Drive Tires

1. Put blocks on each side (front and back) of the steering tires to prevent movement of the lift truck.
2. Put the mast in a vertical position. Put a block under each outer mast channel.
3. Tilt the mast fully forward until the drive tires are raised from the surface.
4. Put additional blocks under the frame behind the drive tires.
5. If the hydraulic system will not operate, use a hydraulic jack under the side of the frame near the front. Make sure that the jack has a capacity equal to at least half the weight of the lift truck. See the nameplate.

How To Raise The Steering Tires

1. Apply the parking brake. Put blocks on both sides (front and back) of the drive tires to prevent movement of the lift truck.
2. Use a hydraulic jack to raise the steering tires. Make sure that the jack has a capacity of at least 2/3 of the total weight of the lift truck as shown on the nameplate.

Put the jack under the steering axle or frame to raise the lift truck. Put blocks under the frame to support the lift truck.

How to Move a Disabled Lift Truck

WARNING

Use extra caution when towing a lift truck if any of the following conditions exist:

- a. Brakes do not operate correctly.**
- b. Steering does not operate correctly.**
- c. Tires are damaged.**
- d. Traction conditions are bad.**
- e. The lift truck must be towed on a slope.**

If the engine cannot run, there is no power available for the hydraulic steering system and the service brakes. This condition can make the lift truck difficult to steer and stop. If the lift truck uses power from the engine to help apply the brakes, the application of the brakes will be more difficult. Poor traction can cause the disabled lift truck or towing vehicle to slide. A slope will also make the lift truck more difficult to stop.

Never lift and move a disabled lift truck unless the disabled lift truck MUST be moved and cannot be towed. A lift truck used to move a disabled lift truck MUST have a capacity rating equal to or greater than the weight of the disabled lift truck. The capacity of the lift truck used to move a disabled lift truck must have a load center equal to half the width of the disabled lift truck. See the nameplate of the disabled lift truck for the approximate total weight. The forks must extend the full width of the disabled lift truck. Put the weight center of the disabled lift truck on load center of the forks. Be careful to not damage the under side of the lift truck.

How To tow The Lift Truck

The towed lift truck must have an operator.

Tow the lift truck slowly.

1. Raise the carriage and forks approximately 30 cm (12 inches) from the surface. Install a chain to prevent the carriage and mast channels from moving.
2. If another lift truck is used to tow the disabled lift truck, that lift
3. truck must have an equal or larger capacity than the disabled

lift truck. Install approximately $\frac{1}{2}$ of a capacity load on the forks of the lift truck that is being used to tow the disabled lift truck. This $\frac{1}{2}$ capacity load will increase the traction of the lift truck. Keep the load as low as possible.

4. Use a towing link made of steel that attaches to the tow pins in the counterweights of both lift trucks.

MD-3 MAIN DISPLAY PAGE



- 1) Water temperature gauge – Indicates water temperature of engine
- 2) Fuel level gauge – Indicates the fuel level of the engine
- 3) Oil pressure gauge – Indicates the oil pressure level of the engine
- 4) Tachometer – Indicates the rpm of the engine
- 5) Filter indicator – Displayed when either the transmission, air or hydraulic filter element needs replacing
- 6) Air filter indicator – Displayed in conjunction with the filter indicator to indicate that the air filter element needs to be replaced.
- 7) Hydraulic filter indicator – Displayed in conjunction with the filter indicator to indicate that the hydraulic filter element needs to be replaced.

- 8) Transmission filter indicator – Displayed in conjunction with the filter indicator to indicate that the transmission filter element needs to be replaced.
- 9) Battery indicator – Displayed when the charge of the engine battery is low
- 10) Parking brake indicator – Displayed when the parking brake is engaged
- 11) Oil pressure indicator – Displayed when the oil pressure of the engine is low
- 12) Fuel level indicator – Displayed when the engine fuel level is low
- 13) Transmission temperature indicator – Displayed when the transmission is at an unsafe temperature.
- 14) Water temperature indicator – Displayed when the engine is at an unsafe temperature.
- 15) Service indicator – Displayed when preventative maintenance of the vehicle needs to be performed. (See adjustments section to reset after maintenancing)
- 16) Hour meter – Displays the number of hours of operation
- 17) F1 function key – Use to view overload display page if vehicle is equipped with a shock sensor.
- 18) Menu key – Use to view the menu display page
- 19) F2 function key – This function key is inactive in this display page
- 20) F3 function key – This function key is inactive in this display page
- 21) F4 function key – This function key is inactive in this display page
- 22) Back function key – This function key is inactive in this display page
- 23) Up function key – This function key is inactive in this display page
- 24) Accept function key – This function key is inactive in this display page
- 25) Down function key – This function key is inactive in this display page

MD-3 MENU DISPLAY PAGE



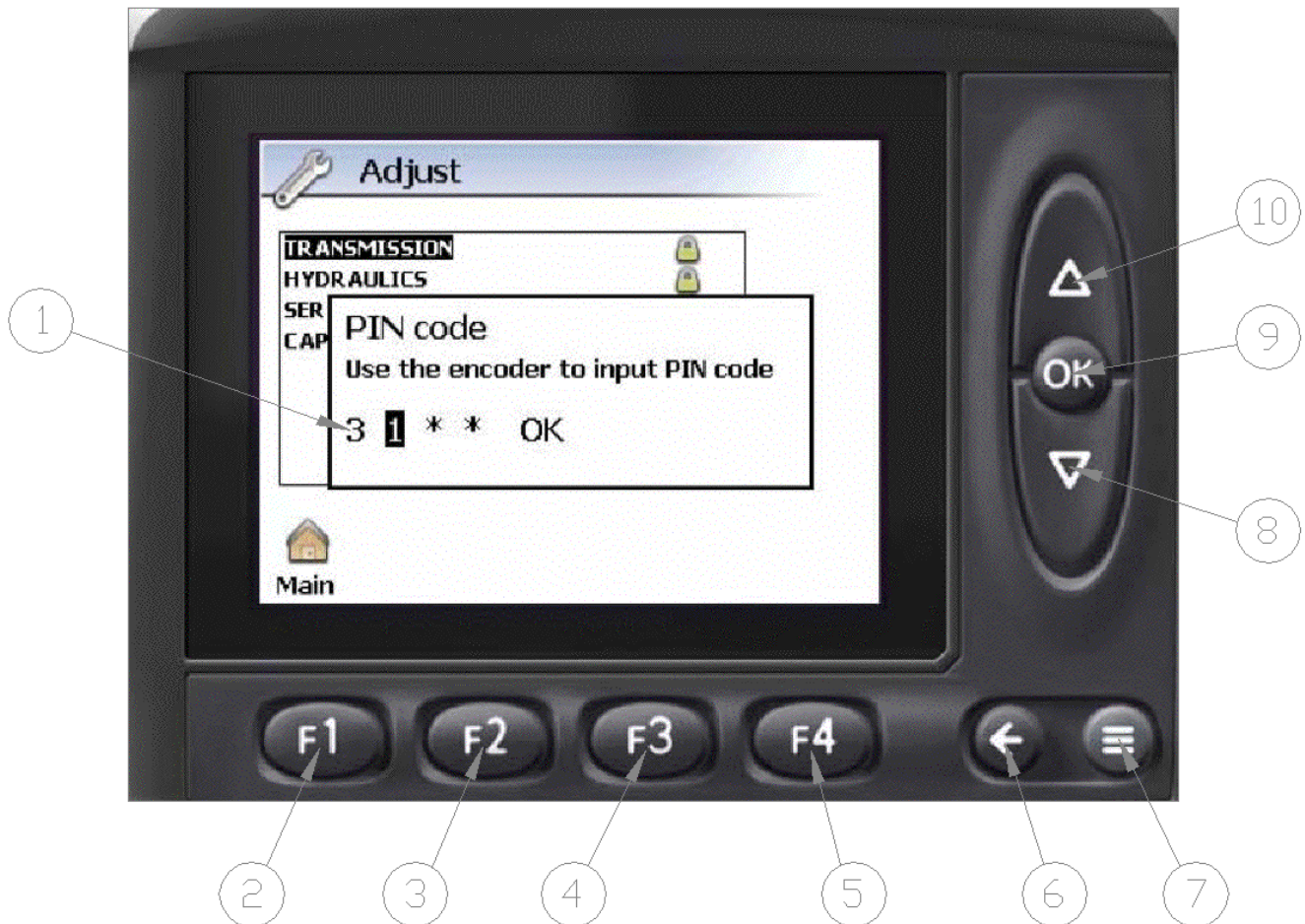
- 1) F1 function key – Use to view adjustment menu
- 2) F2 function key – Use to view measure menu
- 3) F3 function key – Use to view preferences menu
- 4) F4 function key – Use to view information menu
- 5) Back function key – Use to return to main display page
- 6) Menu function key – This function key can also be used to return to the main display page
- 7) Down function key – This function key is inactive in this display page
- 8) Accept function key – This function key is inactive in this display page
- 9) Up function key – This function key is inactive in this display page

MD-3 MAIN ADJUSTMENT DISPLAY PAGE



- 1) Adjustment group – Listed are all item groups that have adjustable parameters
- 2) Group security – If the listed adjustment group is password protected then an icon of a lock will be displayed.
- 3) F1 Function key – Use to return to menu display page
- 4) F2 Function key – This function key is inactive in this display page
- 5) F3 Function key – This function key is inactive in this display page
- 6) F4 Function key – This function key is inactive in this display page
- 7) Back function key – Use to return to menu display page
- 8) Menu function key – Use to view main display page
- 9) Down function key – Use to scroll down and select between adjustment groups
- 10) Accept function key – Use to view adjustment group display page
- 11) Up function key – Use to scroll up and select between adjustment groups

MD-3 SECURITY DISPLAY PAGE



- 1) Pin code – The proper pin code must be entered in for making adjustments to the corresponding adjustment group**Pin code 6499 to make adjustments, pin code 4200 to reset service hour meter
- 2) F1 Function key – This key will tab the cursor to the first digit of the pin code
- 3) F2 Function key – This key will tab the cursor to the second digit of the pin code
- 4) F3 Function key – This key will tab the cursor to the third digit of the pin code
- 5) F4 Function key – This key will tab the cursor to the fourth digit of the pin code
- 6) Back function key – This key will return the display back to the adjustment page
- 7) Menu function key – This key will return the display back to the adjustment page
- 8) Down function key – Use to decrease the highlighted digit of the pin code
- 9) Accept function key – Use to accept the highlighted digit of the pin code
- 10) Up function key – Use to increase the highlighted digit of the pin code

ADJUSTMENT GROUP DISPLAY PAGE **(TRANSMISSION ADJUSTMENT)**



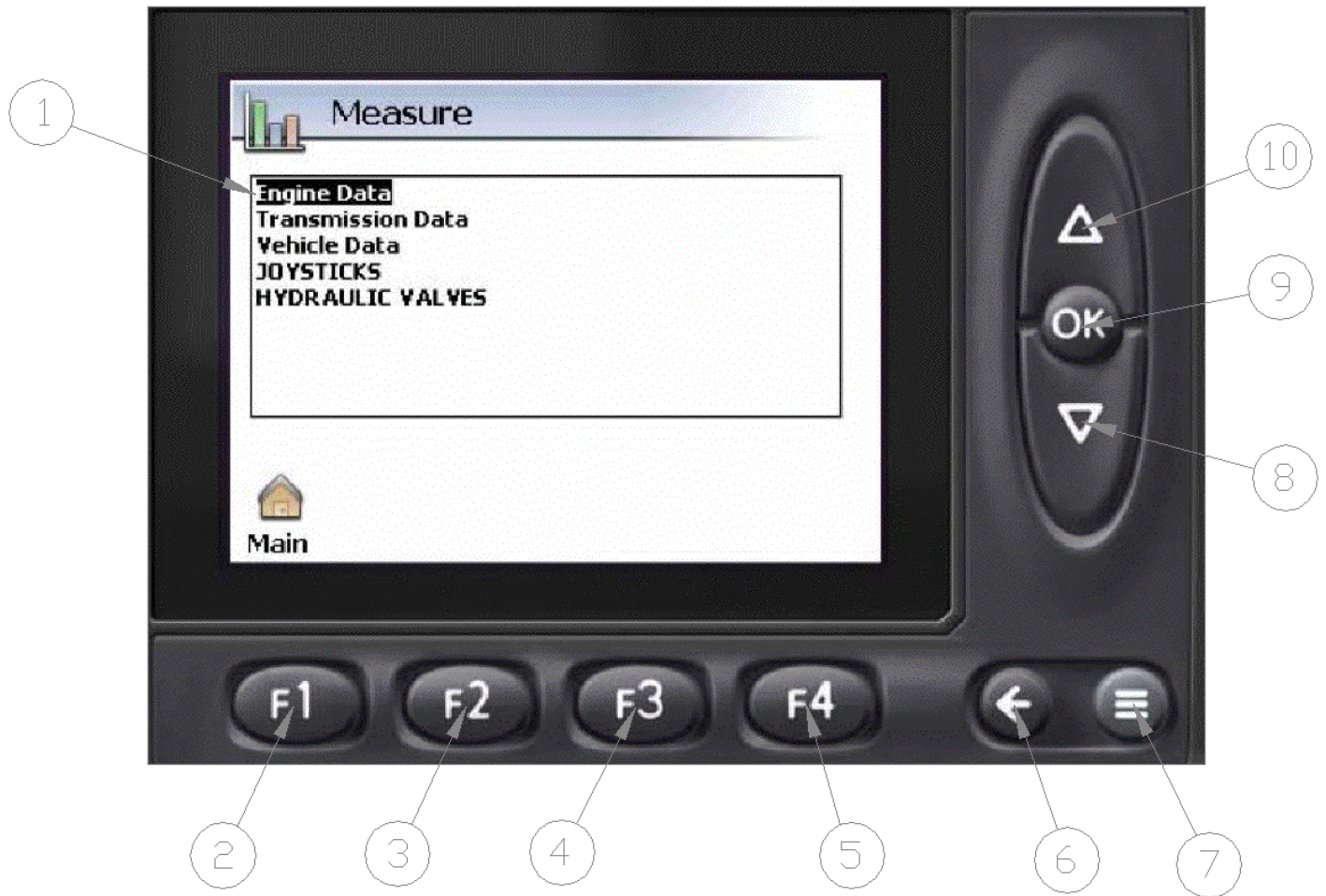
- 1) Transmission adjustment group – Listed are all transmission items that can be adjusted
- 2) F1 Function key – Use to return to menu display page
- 3) F2 Function key – Use to set highlighted parameter to its default value
- 4) F3 Function key – This function key is inactive in this display page
- 5) F4 Function key – This function key is inactive in this display page
- 6) Back function key – Use to return to main adjustment display page
- 7) Menu function key – Use to view main display page
- 8) Down function key – Use to scroll down between transmission adjustments
- 9) Accept function key – Use to view highlighted parameter adjustment page
- 10) Up function key – Use to scroll up between transmission adjustments

PARAMETER ADJUSTMENT PAGE **(TRANSMISSION UPSHIFT)**



- 1) 2nd to 3rd Upshift value – Listed is the current RPM at which the transmission will shift from 2nd gear to 3rd gear
- 2) F1 Function key – Use to return to menu display page
- 3) F2 Function key – Use to set highlighted parameter to its default value
- 4) F3 Function key – This function key is inactive in this display page
- 5) F4 Function key – This function key is inactive in this display page
- 6) Back function key – Use to return to transmission adjustment display page
- 7) Menu function key – Use to view main display page
- 8) Down function key – Use to decrease 2nd to 3rd upshift value
- 9) Accept function key – Use to set 2nd to 3rd upshift value
- 10) Up function key – Use to increase 2nd to 3rd upshift value

MEASURE MENU DISPLAY PAGE



- 1) Measure group – Listed are all item groups that have parameters that can be measured
- 2) F1 Function key – Use to return to menu display page
- 3) F2 Function key – This function key is inactive in this display page
- 4) F3 Function key – This function key is inactive in this display page
- 5) F4 Function key – This function key is inactive in this display page
- 6) Back function key – Use to return to menu display page
- 7) Menu function key – Use to view main display page
- 8) Down function key – Use to scroll down and select between measure groups
- 9) Accept function key – Use to view measure group display page
- 10) Up function key – Use to scroll up and select between measure groups

MEASURE GROUP DISPLAY PAGE (ENGINE DATA – SCALED VALUE)



- 1) Measure parameter – Listed are all parameters and there value/state
- 2) F1 Function key – Use to return to menu display page
- 3) F2 Function key – Use to change values/states from scaled value to raw value
- 4) F3 Function key – This function key is inactive in this display page
- 5) F4 Function key – This function key is inactive in this display page
- 6) Back function key – Use to return to measure menu display page
- 7) Menu function key – Use to view main display page
- 8) Down function key – Use to scroll down between measure parameters
- 9) Accept function key – This function key is inactive in this display page
- 10) Up function key – Use to scroll up between measure parameters

MEASURE GROUP DISPLAY PAGE **(ENGINE DATA – RAW VALUE)**



- 1) Measure parameter – Listed are all parameters and there raw value/state
- 2) F1 Function key – Use to return to menu display page
- 3) F2 Function key – Use to change values/states from raw value to scaled value
- 4) F3 Function key – This function key is inactive in this display page
- 5) F4 Function key – This function key is inactive in this display page
- 6) Back function key – Use to return to measure menu display page
- 7) Menu function key – Use to view main display page
- 8) Down function key – Use to scroll down between measure parameters
- 9) Accept function key – This function key is inactive in this display page
- 10) Up function key – Use to scroll up between measure parameters

PREFERENCES MENU DISPLAY PAGE



- 1) F1 Function key – Use to go to display menu
- 2) F2 Function key – Use to go to date/time menu
- 3) F3 Function key – Use to go to language menu
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to menu display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is inactive in this display page
- 8) Accept function key – This function key is inactive in this display page
- 9) Up function key – This function key is inactive in this display page

DISPLAY MENU DISPLAY PAGE



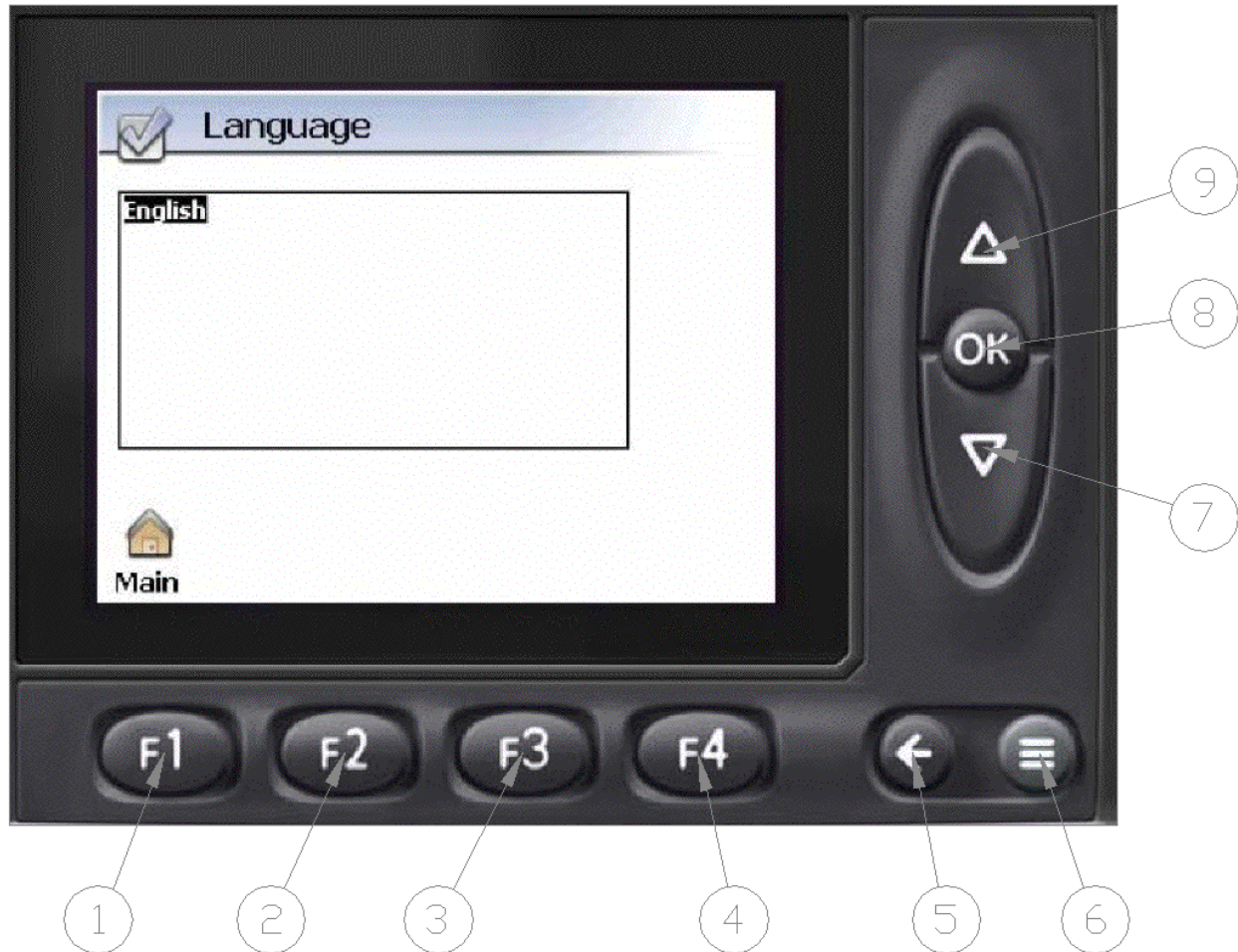
- 1) F1 Function key – Use to go to menu display page
- 2) F2 Function key – Use to select backlight setting
- 3) F3 Function key – Use to select screen saver setting
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to preferences display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is used to lower backlight and screen saver settings when item is highlighted
- 8) Accept function key – Use to accept backlight and screen saver settings
- 9) Up function key – This function key is used to raise backlight and screen saver settings when item is highlighted

DATE/TIME MENU DISPLAY PAGE



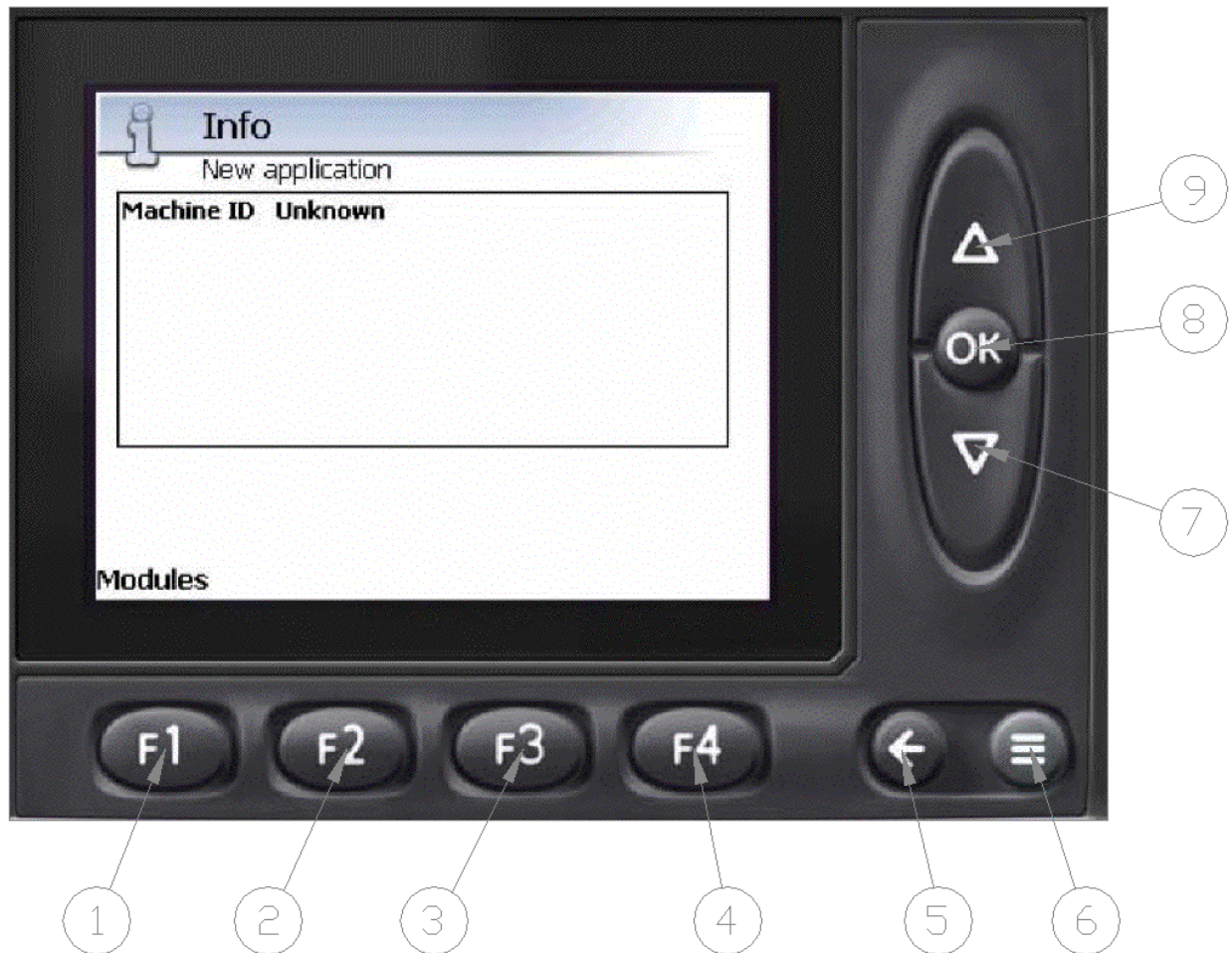
- 1) F1 Function key – Use to select date setting
- 2) F2 Function key – Use to select time setting
- 3) F3 Function key – This function key is inactive in this display page
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to preferences display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is used to lower date and time settings when item is highlighted
- 8) Accept function key – Use to accept date and time settings
- 9) Up function key – This function key is used to raise date and time settings when item is highlighted

LANGUAGE MENU DISPLAY PAGE



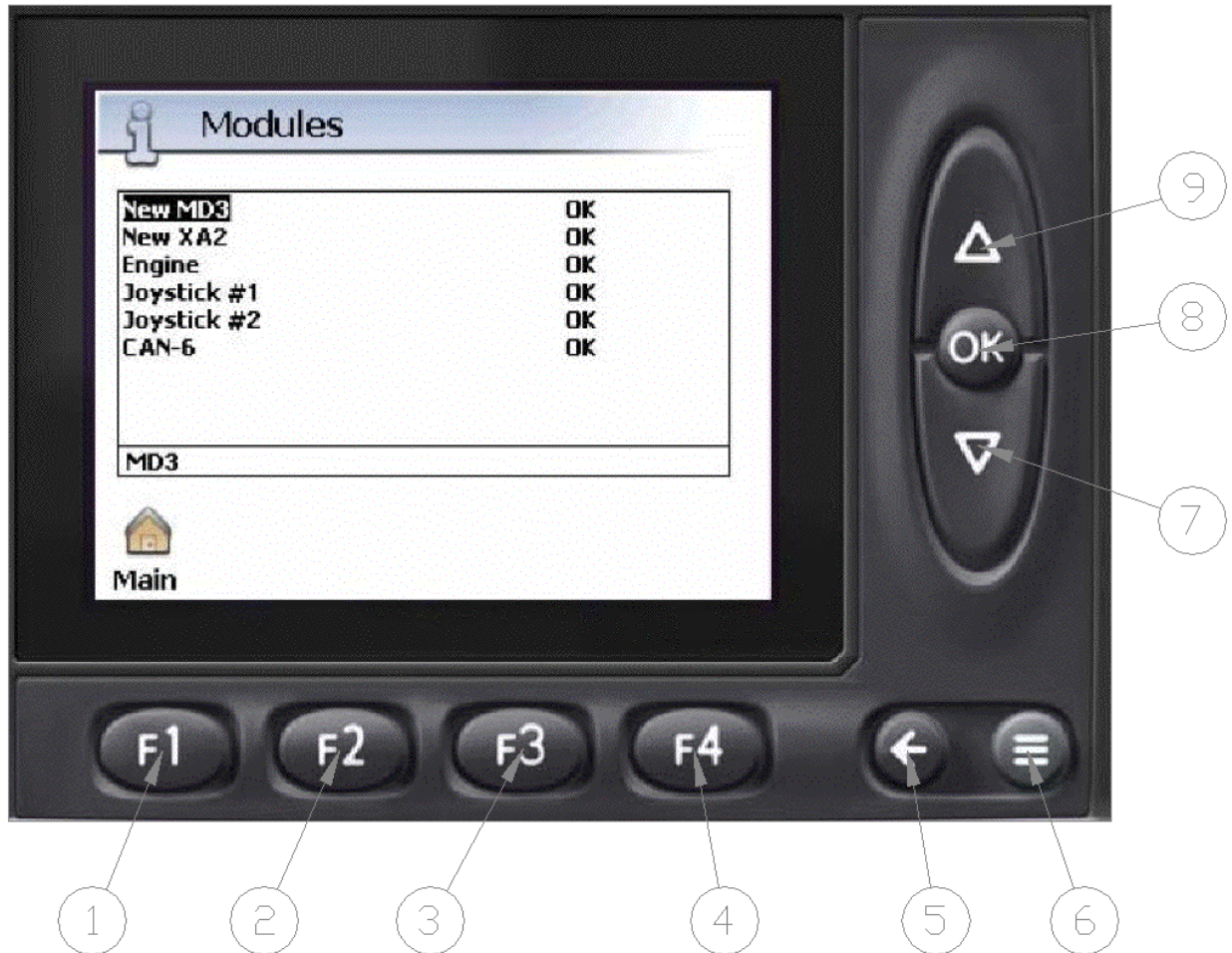
- 1) F1 Function key – Use to go to menu display page
- 2) F2 Function key – This function key is inactive in this display page
- 3) F3 Function key – This function key is inactive in this display page
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to preferences menu display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is inactive in this display page
- 8) Accept function key – Use to return to preferences menu display page
- 9) Up function key – This function key is inactive in this display page

INFO MENU DISPLAY PAGE



- 1) F1 Function key – Use to go to modules menu display page
- 2) F2 Function key – This function key is inactive in this display page
- 3) F3 Function key – This function key is inactive in this display page
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to menu display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is inactive in this display page
- 8) Accept function key – This function key is inactive in this display page
- 9) Up function key – This function key is inactive in this display page

MODULES MENU DISPLAY PAGE



- 1) F1 Function key – Use to go to the menu display page
- 2) F2 Function key – This function key is inactive in this display page
- 3) F3 Function key – This function key is inactive in this display page
- 4) F4 Function key – This function key is inactive in this display page
- 5) Back function key – Use to return to info display page
- 6) Menu function key – Use to view main display page
- 7) Down function key – This function key is used to select module
- 8) Accept function key – This function key is used to accept module
- 9) Up function key – This function key is used to select module

MOUNTING PROCEDURE FOR PRESS-ON TIRES

PROCEDURE:

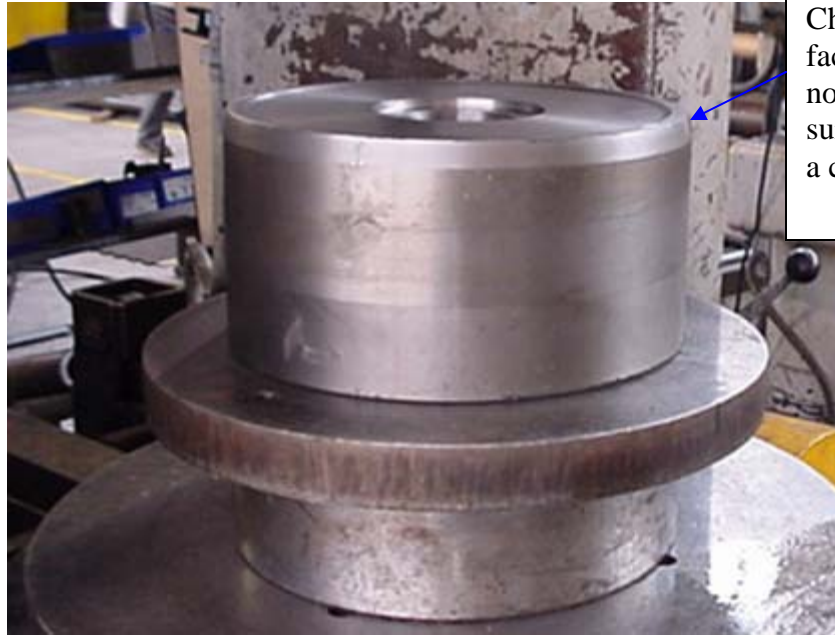
- 1) Lubricate inside diameter of tire to be pressed with Tectyl 506 petroleum grease.
- 2) Verify wheel has a lead-in chamfer or radius containing no sharp edges. If wheel contains any sharp edges they must be removed before continuing.
- 3) Place wheel into press with chamfer/radius side facing up.
- 4) Place the tire onto the wheel making sure that the tire is sitting squarely on the wheel.
- 5) Lower the press slowly and press the tire approx. ½" onto the wheel such that the tire is beyond the lead-in chamfer or radius.
- 6) In order to insure the tire is being pressed squarely, release pressure by raising the press slightly and then re-lower the press onto the tire and continue pressing.
- 7) Press the tire fully onto the wheel and verify that the required pressure does not increase significantly throughout the pressing process. If the required pressing pressure does increase significantly then see the precautions section listed below.
- 8) Release pressure by raising the press fully. If the wheel assembly only requires a single tire, then this completes the operation. If the wheel assembly requires dual tires, then proceed with steps 9 thru 14.

- 9) Place the second tire directly on top of the first tire without changing the orientation and location of the wheel assembly in the press.
- 10) Lower the press slowly and press the second tire approx. ½" onto the wheel such that the tire is beyond the lead-in chamfer or radius.
- 11) In order to insure the second tire is being pressed squarely, release pressure by raising the press slightly and then re-lower the press onto the tire and continue pressing.
- 12) Press the second tire fully onto the wheel and verify that the required pressure does not increase significantly throughout the pressing process. If the required pressing pressure does increase significantly then see the precautions section listed below.
- 13) Release pressure by raising the press fully.
- 14) Remove the new tire and wheel assembly from the press.

PRECAUTIONS:

- 1) If the pressing pressure is seen to be increasing significantly while pressing a tire then stop the press and release pressure by raising the press. If a curl or several curls of steel have formed in front of the tire at its inside diameter then the tire/wheel assembly must be turned over and the tire needs to be pressed off. Finally turn the wheel back over and repress the tire onto the wheel from the opposite end using the procedure above.
- 2) If the pressing pressure is seen to be increasing significantly while pressing the tire but no curls of steel have formed then the tire maybe slightly undersized. Therefore continue to press the tire onto the wheel using the procedure above. Keep a close watch that no curls of steel form in front of the tire.

Press-on Tire



Make sure the lead in Chamfer or Radius is facing up and there are no sharp edges. Make sure the wheel sits on a clean flat surface.

Lubricate the inside diameter of the tire to pressed with Tectyl 506 petroleum grease





Look for curl metal in front of the tire during pressing, Should curling occur turn the tire/wheel over and press tire off.

Place the tire onto the wheel making sure that the tire is sitting squarely on the wheel.

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Section 1 Introduction

Standard Single Reduction Carriers Without Differential Lock

Rockwell single reduction standard carriers, **Figure 1**, are used in most Rockwell single axles, rear of tandem axles and front drive steering axles.

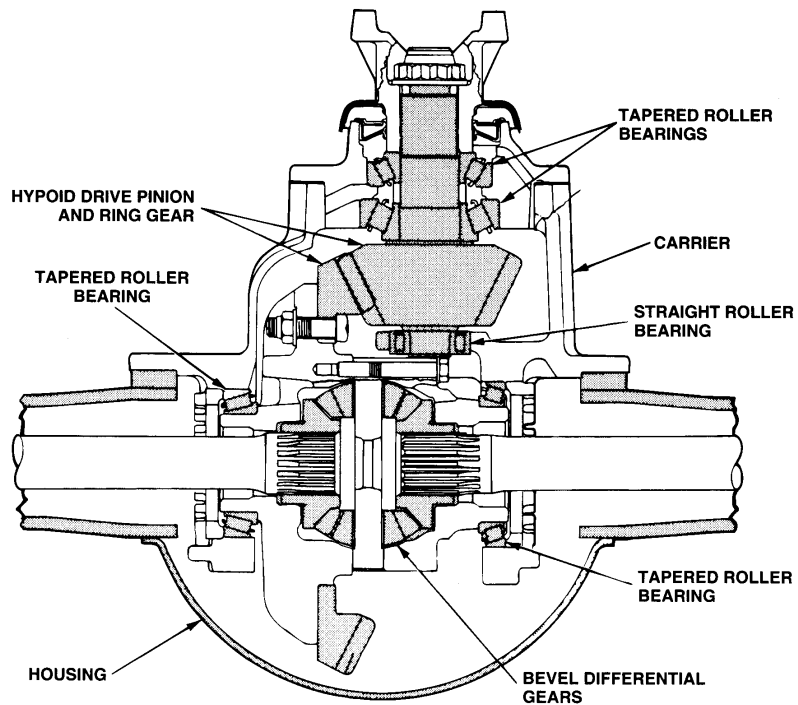
The single reduction carrier models are front mounted into the axle housing. These carriers have a hypoid

drive pinion and ring gear set and bevel gears in the differential assembly.

A straight roller bearing (spigot) is mounted on the head of the drive pinion. All other bearings in the carrier are tapered roller bearings.

When the carrier operates, there is normal differential action between the wheels all the time.

Figure 1



Section 2 Disassembly

Remove Differential Carrier from Axle Housing



WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

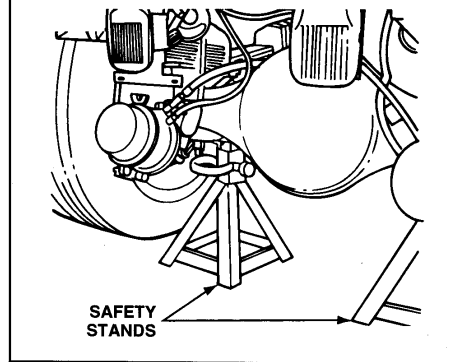
1. Raise the end of vehicle where the axle is mounted. Use a jack or other lifting tool, and place safety stands under each side of the axle.
Figure 2.



WARNING

Do not work under a vehicle supported only by a jack. Jacks can slip or fall over resulting in serious personal injury. Always use safety stands.

Figure 2

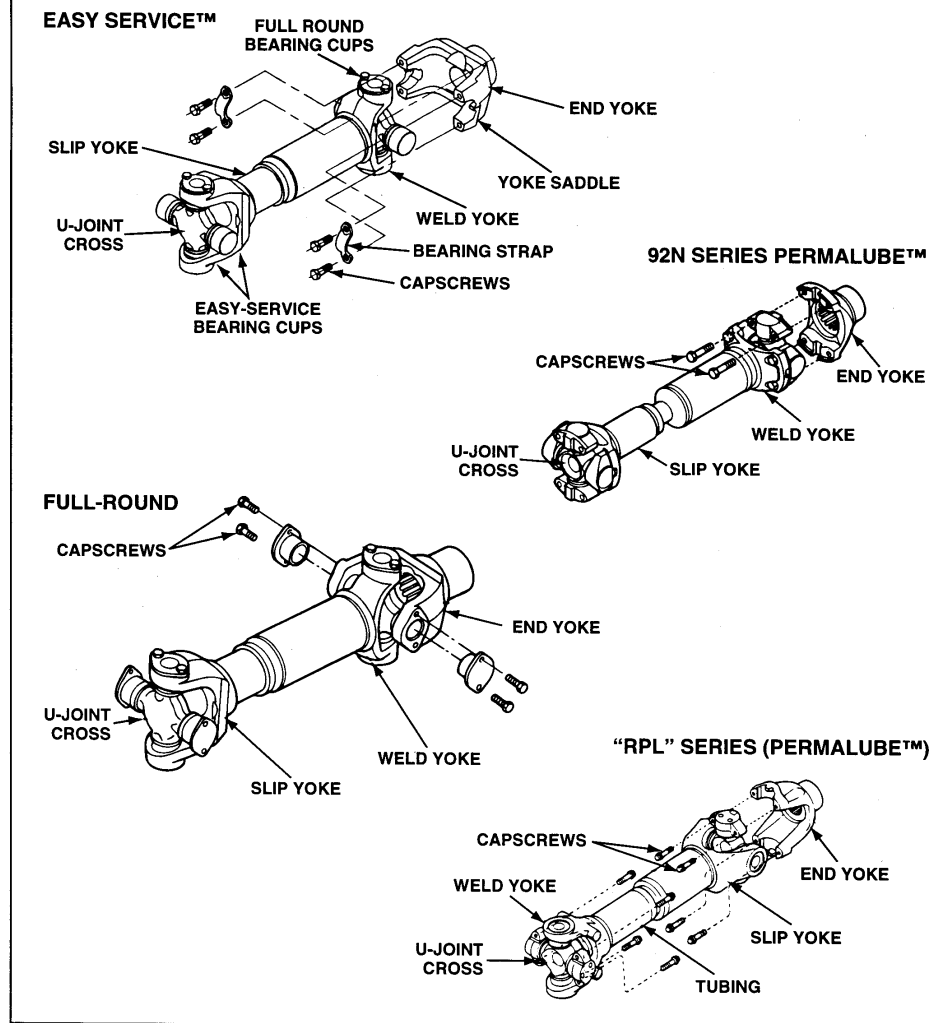


2. Place jack stands under each spring seat of the axle to hold vehicle in the raised position.
Figure 2.
3. Remove the plug from bottom of axle housing and drain lubricant from the assembly.

Section 2 Disassembly

4. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier.
Figure 3.
5. Remove the capscrews and washers or stud nuts and washers from the flanges of both axle shafts.

Figure 3



Section 2 Disassembly

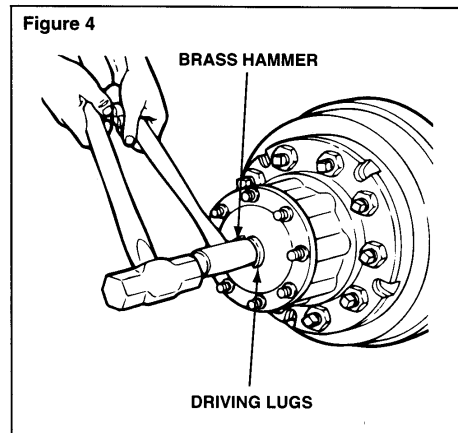
- Loosen the tapered dowels if applicable, in the axle flanges of both axle shafts using either the **Brass Drift** or the **Air Hammer Vibration** method.

Brass Drift Method

WARNING

Wear safe eye protection. Do not directly strike or hit the round driving lugs on the flange of the axle shaft. Striking the lugs can cause them to break off from the axle shaft hub resulting in serious personal injury.

- Hold a 1-1/2 inch diameter brass drift against the center of the axle shaft, inside the round driving lugs. **Figure 4.**

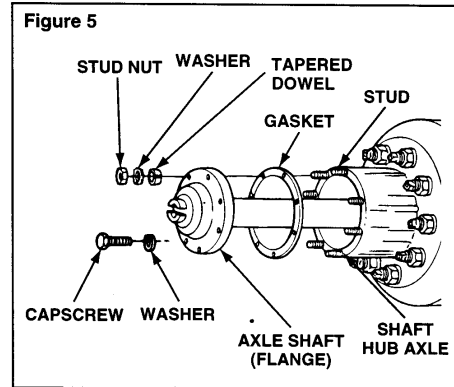


NOTE:

A 1-1/2 inch diameter brass hammer can be used as a drift.

- Strike the end of the drift with a large hammer (five to six pounds) and the axle shaft and tapered dowels will loosen.
- Mark to identify each axle shaft before it is removed from the axle assembly.

- Remove the tapered dowels and separate the axle shafts from the main axle hub assembly. **Figure 5.**



- Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

Air Hammer Vibration Method

WARNING

Wear safe eye protection when using an air hammer. When using power tools, axle components can loosen and break off causing serious personal injury.

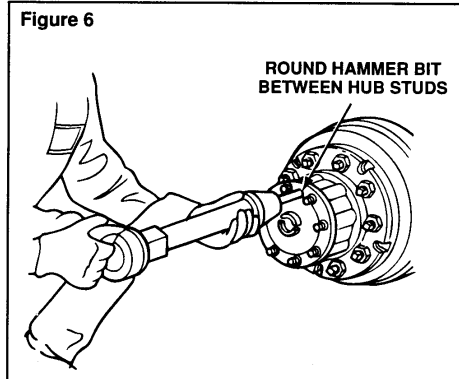
CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

- Use a round hammer bit and an air hammer such as Chicago Pneumatic CP-4181-Puller, or equivalent, to loosen tapered dowels and axle shaft.

Section 2 Disassembly

- Place the round hammer bit against the axle shaft (flange) between the hub studs. Operate the air hammer at alternate locations between the studs to loosen the tapered dowels and axle shaft from the hub. **Figure 6.**



- Mark to identify each axle shaft before it is removed from the axle assembly.
- Remove the tapered dowels and separate the axle shaft from the main axle hub assembly. **Figure 5.**
- Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

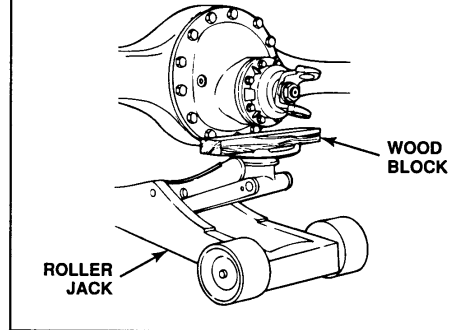
CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

Carrier Removal from Axle

- Place a hydraulic roller jack under the differential carrier to support the assembly. **Figure 7.**
- Remove all but the top two carrier to housing capscrews or stud nuts and washers.
- Loosen the top two carrier-to-housing fasteners and leave attached to the assembly. The fasteners will hold the carrier in the housing.
- Loosen the differential carrier in the axle housing. Use a leather mallet to hit the mounting flange of carrier at several points.
- After the carrier is loosened, remove the top two fasteners.

Figure 7

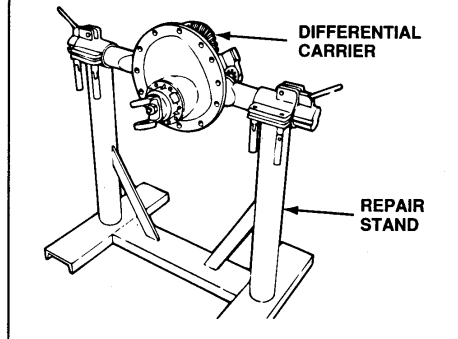


CAUTION

When using a pry bar be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

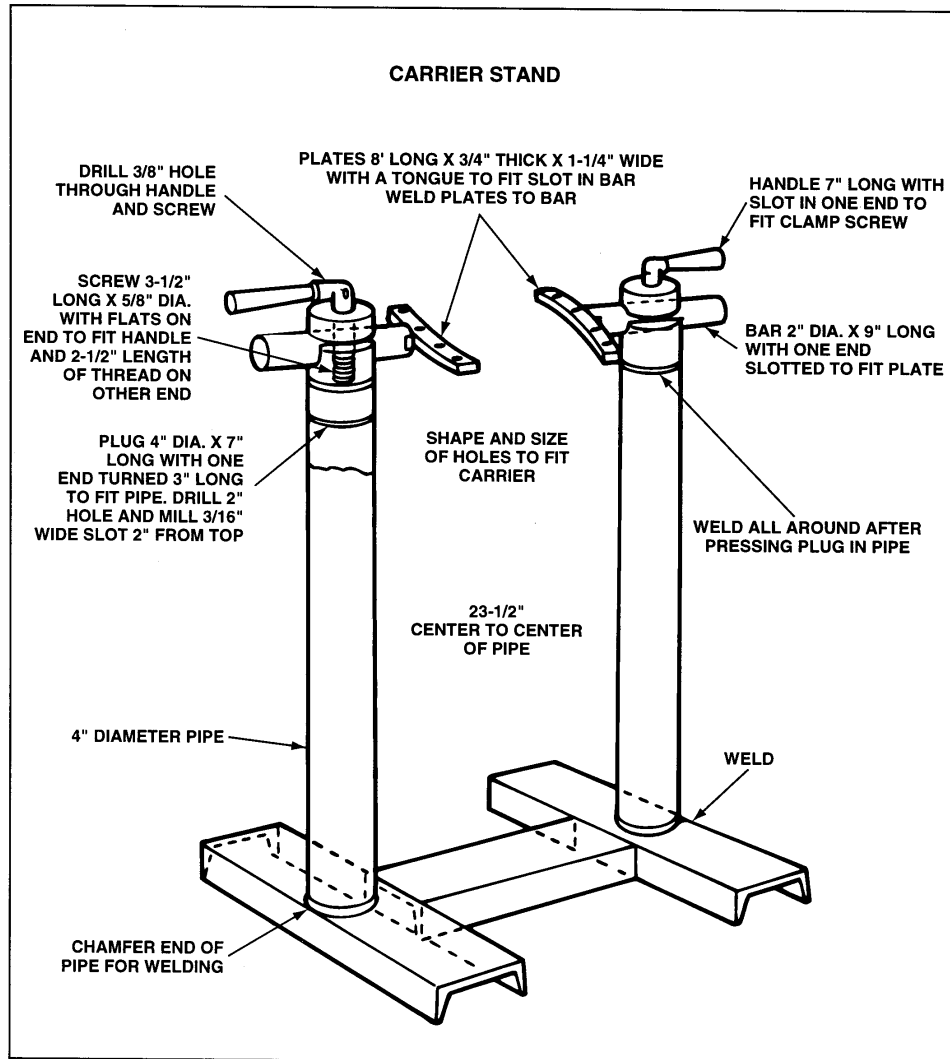
- Carefully remove the carrier from the axle housing using the hydraulic roller jack. Use a pry bar that has a round end to help remove the carrier from the housing.
- Lift the differential carrier by the input yoke or flange and place the assembly in a repair stand. **Figure 8.** Use a lifting tool for this procedure. Do not lift by hand. A carrier stand can be built by referring to the drawing on page 8.

Figure 8



Section 2 Disassembly

A carrier stand, part number J 3409-D is available from Kent-Moore, Heavy-Duty Division, 29784 Little Mack, Roseville, Michigan 48066-2298.



Section 2 Disassembly

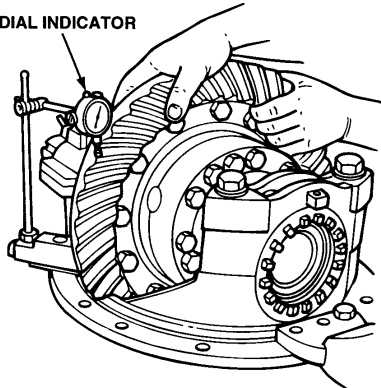
Remove the Differential and Ring Gear from the Carrier

NOTE:

Before working on the differential carrier, inspect the hypoid gear set for damage. If inspection shows no damage, the same gear set can be used again. Measure the backlash of the gear set and make a record of the dimension. Figure 9. (Refer to procedure on page 48, steps 1-5.) During differential reassembly, adjust the backlash to the original recorded dimension when the gear set is installed into the carrier.

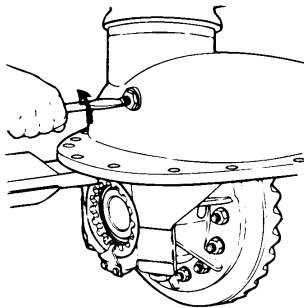
Figure 9

DIAL INDICATOR



1. Loosen the jam nut on the thrust screw
Figure 10.

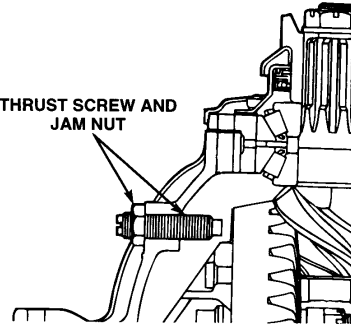
Figure 10



2. Remove the thrust screw and jam nut from the differential carrier. Figure 11.

Figure 11

THRUST SCREW AND
JAM NUT



3. Rotate the differential carrier in the repair stand until the ring gear is at the top of the assembly.
4. Mark one carrier leg and bearing cap to correctly match the parts during carrier assembly. Mark the parts using a center punch and hammer.

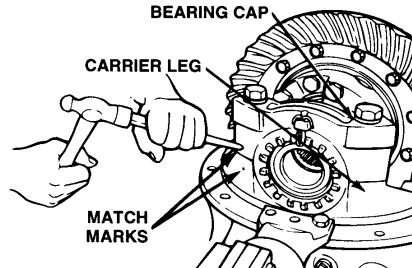
Figure 12.

Figure 12

BEARING CAP

CARRIER LEG

MATCH
MARKS



Section 2 Disassembly

5. Remove the cotter keys , pins or lock plates that hold the two bearing adjusting rings in position. Use a small drift and hammer to remove pins. Each lock plate is held in position by two capscrews. **Figure 13.**
6. Remove the capscrews and washers that hold the two bearing caps on the carrier. Each cap is held in position by two capscrews and washers. **Figure 14.**
7. Remove the bearing caps and bearing adjusting rings from the carrier: **Figure 15.**
8. Safely lift the main differential and ring gear assembly from the carrier. Place the assembly on a work bench. **Figure 16.**

Figure 13

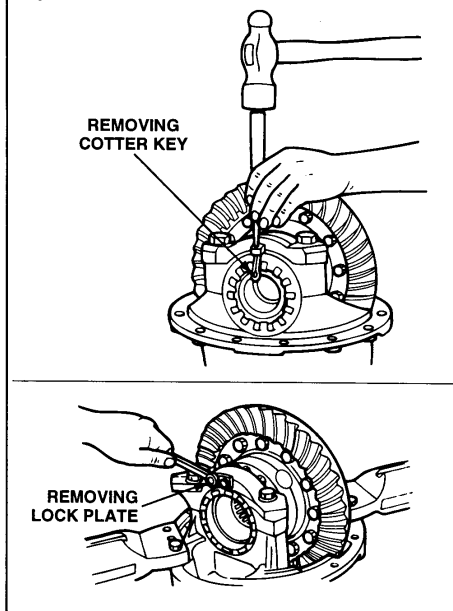


Figure 14

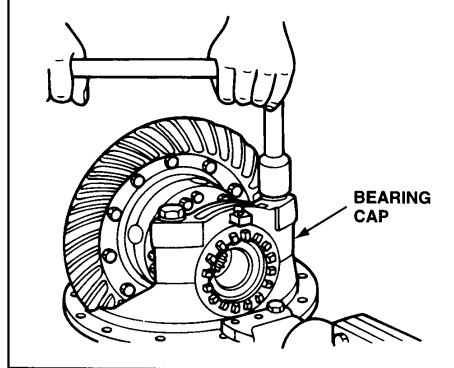


Figure 15

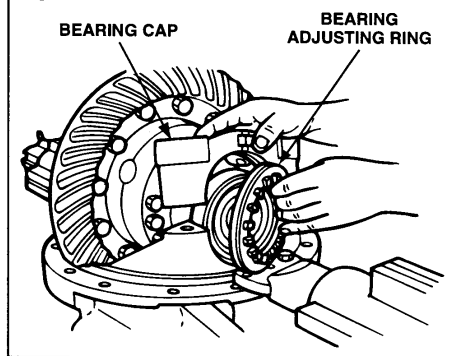
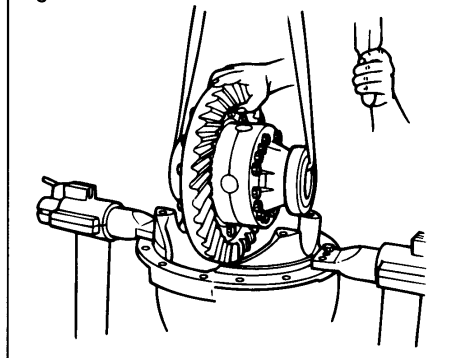


Figure 16

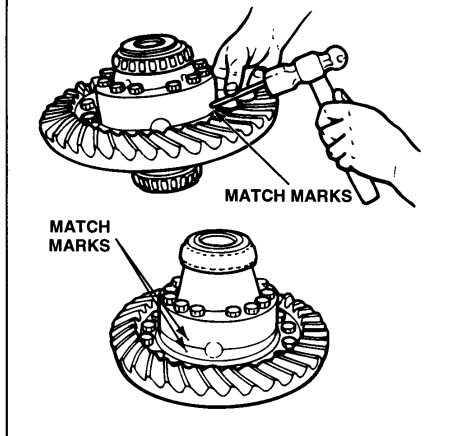


Section 2 Disassembly

Disassemble the Differential and Ring Gear Assembly

1. If the matching marks on the case halves of the differential assembly are not visible, mark each case half with a center punch and hammer. The purpose of the marks is to match the plain half and flange half correctly when you assemble the carrier. **Figure 17.**

Figure 17



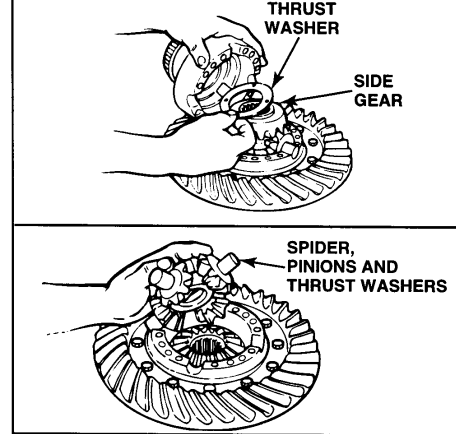
2. Remove the capscrews and washers or bolts, nuts and washers that hold the case halves together.

WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

3. Separate the case halves. If necessary, use a brass, plastic or leather mallet to loosen the parts.
4. Remove the differential spider (cross), four pinion gears, two side gears and six thrust washers from inside the case halves. **Figure 18.**
5. If the ring gear needs to be replaced, remove the bolts, nuts, and washers that hold the gear to the flange case half.

Figure 18



CAUTION

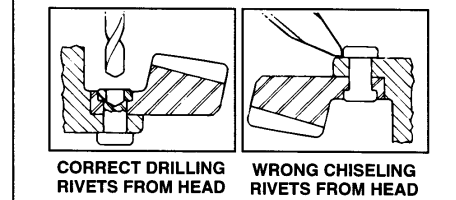
Do not remove the rivets or rivet heads with a chisel and hammer. Using a flat edge tool can cause damage to the flange case. Refer to Figure 19.

WARNING

Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

6. If rivets hold the ring gear to the flange case half, remove the rivets as follows:
7. Carefully center punch each rivet head in the center, on the ring gear side of the assembly.
8. Drill each rivet head on the ring gear side of the assembly to a depth equal to the thickness of one rivet head. Use a drill bit that is 1/32 of an inch smaller than the body diameter of the rivets. **Figure 19.**

Figure 19



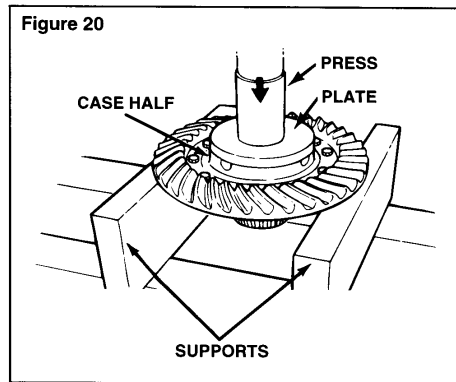
Section 2 Disassembly

9. Press the rivets through holes in the ring gear and flange case half. Press from the drilled rivet head.

WARNING

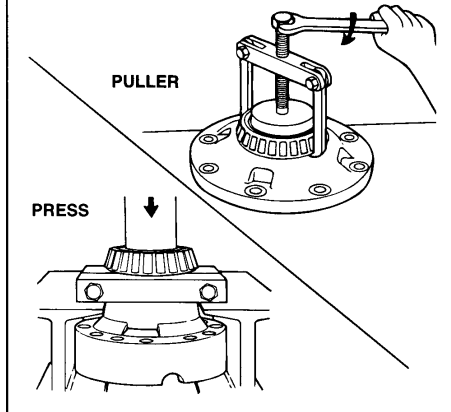
Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

10. Separate the case half and ring gear using a press. Support the assembly under the ring gear with metal or wood blocks and press the case half through the gear. **Figure 20.**



11. If the differential bearings need to be replaced, remove the bearing cones from the case halves. Use a bearing puller or press. **Figure 21.**

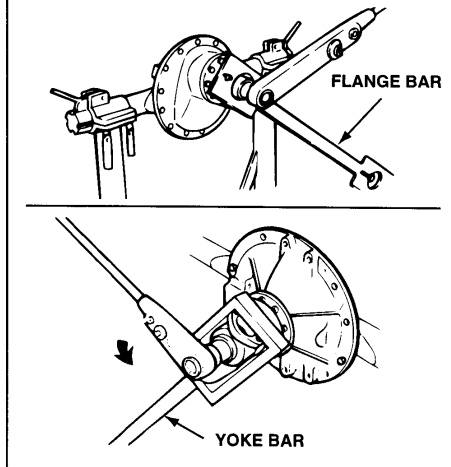
Figure 21



Remove the Drive Pinion and Bearing Cage from Carrier

1. Fasten a flange bar to the input yoke or flange. When the nut is removed, the bar will hold the drive pinion in position. **Figure 22.**

Figure 22



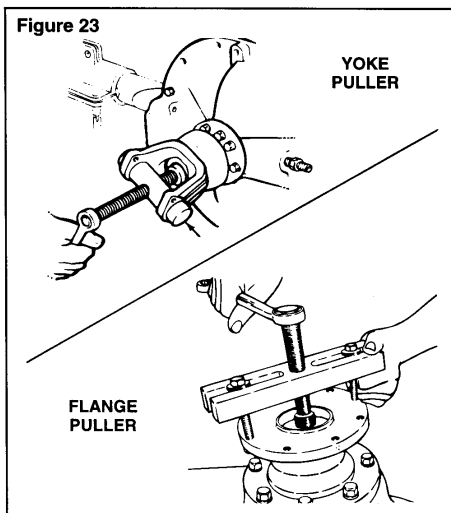
Section 2 Disassembly

2. Remove the nut and washer from the drive pinion. **Figure 22.**
3. Remove the yoke or flange bar.

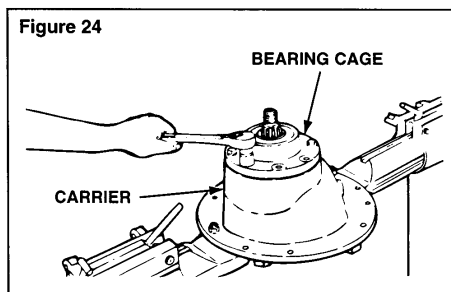
CAUTION

Do not use a hammer or mallet to loosen and remove the yoke or flange. A hammer or mallet can damage the parts and cause driveline runout, or driveline imbalance problems after carrier to driveline assembly.

4. Remove the yoke or flange from the drive pinion. If the yoke or flange is tight on the pinion, use a puller for removal. **Figure 23.**



5. Remove the capscrews and washers that hold the bearing cage in the carrier. **Figure 24.**



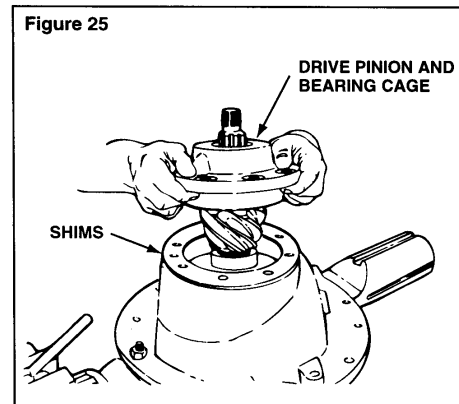
WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

CAUTION

Do not use a pry bar to remove the bearing cage from the carrier. A pry bar can damage the bearing cage, shims and carrier.

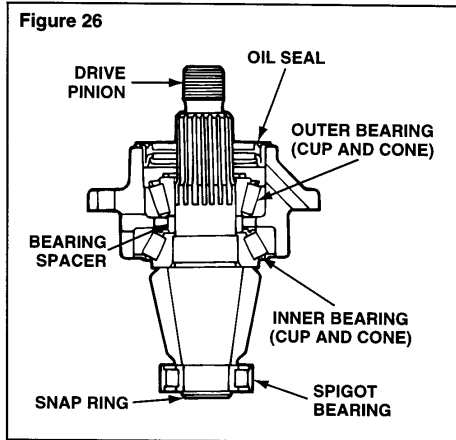
6. Remove the drive pinion, bearing cage and shims from the carrier. If the bearing cage is tight in the carrier, hit the bearing cage at several points around the flange area with a leather, plastic or rubber mallet. **Figure 25.**



7. If the shims are in good condition, keep the shims together for use later when the carrier is assembled.
8. If shims are to be discarded because of damage, first measure the total thickness of the pack. Make a note of the dimension. The dimension will be needed to calculate the depth of the drive pinion in the carrier when the gear set is installed.

Section 2 Disassembly

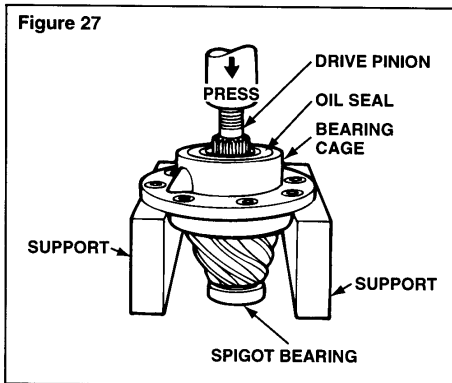
Disassemble the Drive Pinion and Bearing Cage



WARNING

Observe all **WARNINGS** and **CAUTIONS** provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

1. Place the drive pinion and bearing cage in a press. The pinion shaft must be toward the top of the assembly. **Figure 27.**



2. Support the bearing cage under the flange area with metal or wood blocks. **Figure 27.**
3. Press the drive pinion through the bearing cage. **Figure 27.**

NOTE:

The inner bearing cone and bearing spacer will remain on the pinion shaft.

WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

4. If a press is not available, use a leather, plastic or rubber mallet to drive the pinion through the bearing cage.

CAUTION

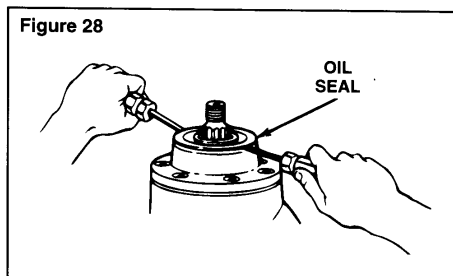
Be careful when removing the seal. Do not damage the wall of bore. Damage to the bore wall can result in oil leaks.

NOTE:

When the oil seal has been removed, always replace it with a new triple-lip (main) seal during component reassembly.

5. If the pinion oil seal is mounted directly in the outer bore of the bearing cage, remove the seal at this time.

Be careful that you do not damage the mounting surfaces of the bearing cage. **Figure 28.**



Section 2 Disassembly

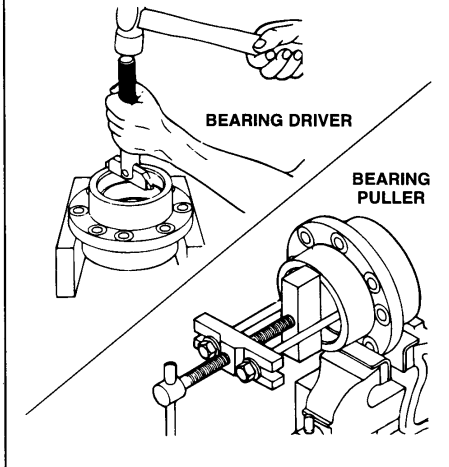
WARNING

Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

6. If the pinion bearings need to be replaced, remove the inner and outer bearing cups from the inside of cage. Use a press and sleeve, bearing puller or a small drift hammer. The type of tool used depends on the design of the bearing cage. **Figure 29.**

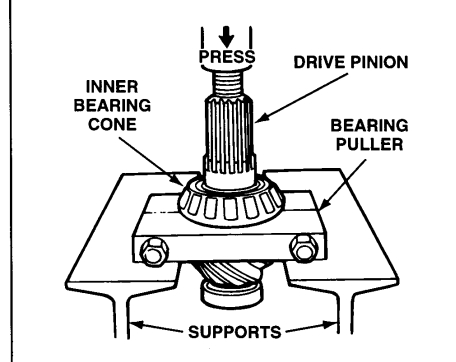
When a press is used, support the bearing cage under the flange area with metal or wood blocks.

Figure 29



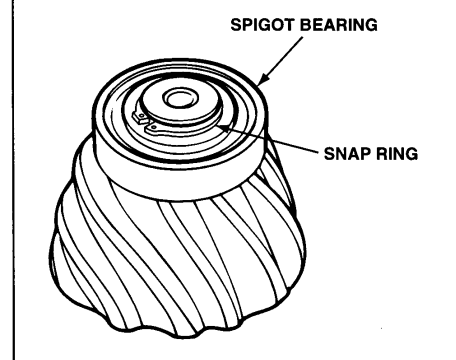
7. If the pinion bearings need to be replaced, remove the inner bearing cone from the drive pinion with a press or bearing puller. The puller **must** fit under the inner race of the cone to remove the cone correctly without damage. **Figure 30.**

Figure 30



8. If the spigot bearing needs to be replaced, place the drive pinion in a vise. Install a soft metal cover over each vise jaw to protect the drive pinion.
9. Remove the snap ring from the end of drive pinion with snap ring pliers that expand. **Figure 31.**

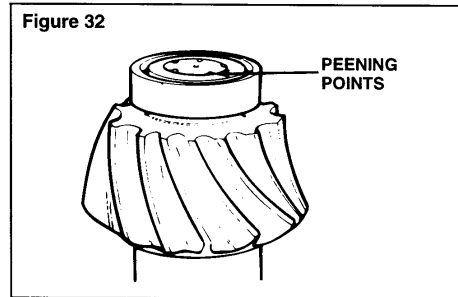
Figure 31



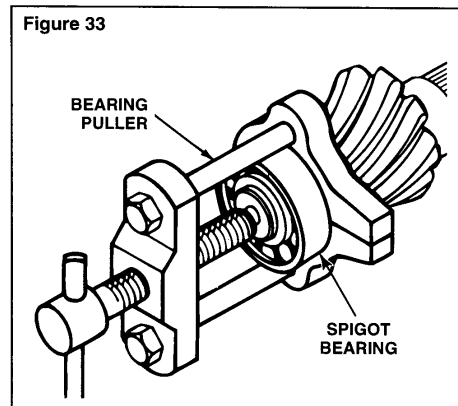
Section 2 Disassembly

NOTE:

Some spigot bearings are fastened to the drive pinion with a special peening tool. Figure 32.

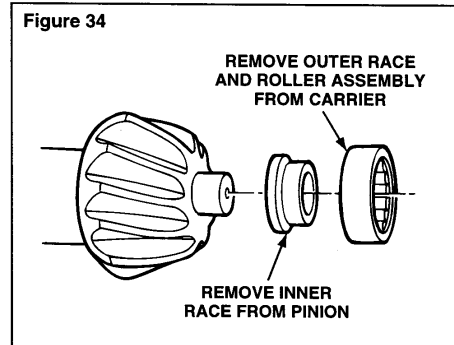


10. Remove the spigot bearing from the drive pinion with a bearing puller. **Figure 33.**



NOTE:

Some spigot bearings are a two-piece assembly. Remove the inner race from the pinion with a bearing puller. Remove the outer race/roller assembly from carrier with a drift or a press. Figure 34.



Section 3

Preparing the Parts for Assembly

Cleaning Ground and Polished Parts



WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

1. Use a cleaning solvent to clean ground or polished parts or surfaces. Kerosene or diesel fuel oil can be used for this purpose. **Do not use gasoline.**



WARNING

Be careful when using cleaning solvents. Follow the solvent manufacturer's instructions for safe use and to prevent personal injury.

2. Use a tool with a flat blade, if required, to remove sealant material from parts. Be careful not to damage the polished or smooth surfaces.



CAUTION

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage these parts. Isopropyl alcohol, kerosene or diesel fuel can be used for this purpose. If required, use a sharp knife to remove gasket material from parts. Be careful not to damage the ground or polished surfaces.

3. **Do not** clean ground or polished parts with water or steam. Do not immerse ground or polished parts in a hot solution tank or use strong alkaline solutions for cleaning, or the smooth sealing surface may be damaged.

Cleaning Rough Parts

1. Clean rough parts with the same method as cleaning ground and polished parts.
2. Rough parts can be cleaned in hot solution tanks with a weak or diluted alkaline solution.
3. Parts must remain in hot solution tanks until heated and completely cleaned.



WARNING

If you use cleaning solvents, hot solution tanks or alkaline solutions incorrectly, serious personal injury can occur. To prevent serious personal injury, follow the instructions supplied by the manufacturer of these products. Do not use gasoline to clean parts. Gasoline can explode and cause serious personal injury.

4. Parts must be washed with water until all traces of the alkaline solution are removed.

Cleaning Axle Assemblies

1. A complete axle assembly can be steam cleaned on the outside to remove dirt.
2. Before the axle is steam cleaned, close or place a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Drying Parts After Cleaning

1. Parts must be dried immediately after cleaning and washing.
2. Dry the parts using soft, clean paper or cloth rags.
3. Except for bearings, parts can be dried with compressed air.



CAUTION

Damage to bearings can result when they are rotated and dried with compressed air.

Preventing Corrosion on Cleaned Parts

1. Apply axle lubricant to cleaned and dried parts that are not damaged and are to be assembled.
2. To store parts, apply a special material that prevents corrosion to all surfaces. Wrap cleaned parts in a special paper that will protect the parts from moisture and prevent corrosion during storage.

Section 3

Preparing the Parts for Assembly

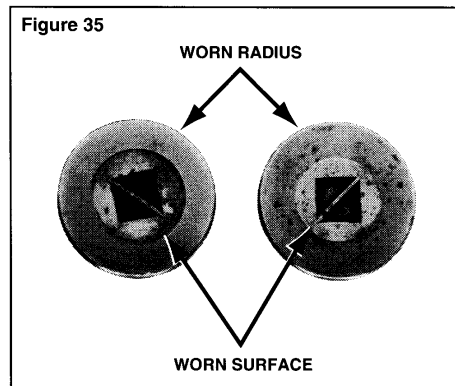
Inspecting Parts

It is very important to inspect all parts carefully and completely before the axle or carrier is assembled. Inspect all parts for wear and replace damaged parts. Replacement of damaged or worn parts now, will prevent failure of the assembly later.

1. Inspecting Tapered Roller Bearings:

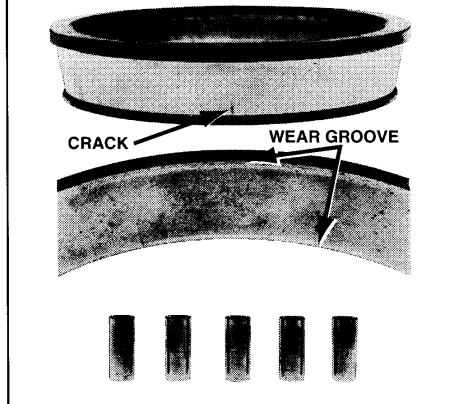
Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If any of the following conditions exist, the bearing **must** be replaced.

- a. The center of large-diameter end of rollers worn level with or below the outer surface. **Figure 35.**



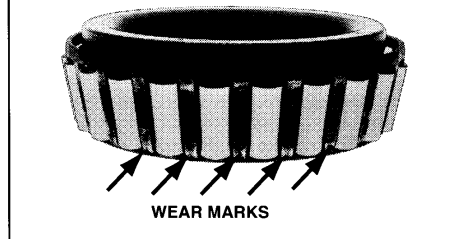
- b. The radius at large-diameter end of rollers worn to a sharp edge. **Figure 35.**
- c. A visible roller groove in the cup or cone inner race surfaces. The groove can be seen at the small- or large-diameter end of both parts. **Figure 36.**

Figure 36



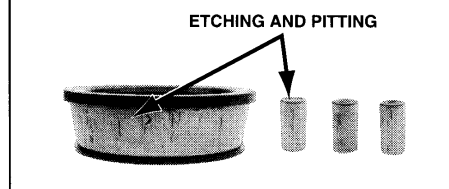
- d. Deep cracks or breaks in the cup, cone inner race or roller surfaces. **Figure 36.**
- e. Bright wear marks on the outer surface of the roller cage. **Figure 37.**

Figure 37



- f. Damage on rollers and on surfaces of the cup and cone inner race that touch the rollers. **Figure 38.**

Figure 38

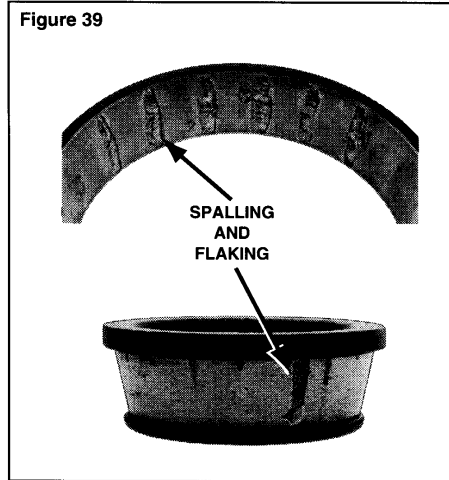


Section 3

Preparing the Parts for Assembly

- g. Damage on the cup and cone inner race surfaces that touch the rollers. **Figure 39.**

Figure 39



CAUTION

Hypoid drive pinions and ring gears are machined in matched sets. When a drive pinion or ring gear of a hypoid set needs to be replaced, both drive gear and pinion must be replaced at the same time.

2. Inspect hypoid pinions and gears for wear or damage. Gears that are worn or damaged **must** be replaced.

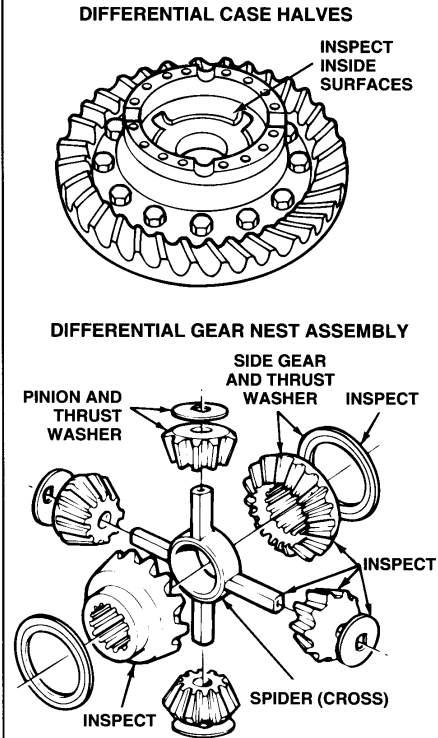
CAUTION

Always replace thrust washers, differential side gears and pinion gears in full matched sets. A higher stress on original parts and early failure of the entire assembly will result if a new part is used in combination with parts that are older or worn.

3. Inspect the Main Differential Assembly:

Inspect the following parts for wear or stress. Parts that are damaged **must** be replaced. **Figure 40.**

Figure 40



- a. Inside surfaces of both case halves.
 - b. Both surfaces of all thrust washers.
 - c. The four trunnion ends of the spider (cross).
 - d. Teeth and splines of both differential side gears.
 - e. Teeth and bore of all differential pinions.
4. Inspect Axle Shafts:
 - a. Inspect axle shafts for wear and cracks at the flange, shaft and splines.
 - b. Replace axle shafts, if required.

Section 3

Preparing the Parts for Assembly

WARNING

Be careful when using a cleaning solvent. Follow the solvent manufacturer's instructions for safe use to prevent serious personal injury.

- d. Clean the damaged area inside and outside the housing. Cleaning solvent can be used.
- e. Grind the damaged weld to the base metal.
- f. Warm the complete axle housing to a temperature of 70°F–80°F (21°C–27°C) or higher.
- g. Before you start welding, heat the damaged area to be repaired to approximately 300°F (149°C).
- h. Use a 70,000 psi tensile weld material and the correct voltage and amperage for the diameter weld rod used. Examples of weld rods that can be used are E-7018 or ER-70S-3.

CAUTION

If the E-7018 weld rod is used, the rod must be kept dry. Electrodes that are not stored in the correct sealed containers must be heated at 700°F (371°C) for one hour before welding. Wet electrodes must be dried at 180°F (82°C) for one to two hours and then heated at 700°F (371°C) for one hour before welding.

- i. Fill in the weld gap as follows:

CAUTION

Do not connect the ground cable at any point on the axle assembly that will place a bearing between the ground cable and weld area. If a bearing is between the ground cable and weld, the bearing will be damaged because of electrical arcing in the bearing and bearing track areas.

A good location to connect the ground cable is the spring mounting pad of the housing.

1. The opening in cover welds **must** be filled level with the old weld.
2. The opening in seam welds **must** be ground out to 70% of the wall thickness. The wall thickness can be measured at the carrier opening of housing.
3. Clean the new weld area. Carefully remove all the rough weld material.

4. Install the differential carrier and axle shafts.
5. Fill the axle assembly with the correct amount of lubricant. Refer to Rockwell Field Maintenance Manual No. 1 for information on lubricants.

NOTE:

Before welding brackets or other components to the axle housing, contact Rockwell for proper welding procedures.

Bending or Straightening Drive Axle Housings

Rockwell International is emphatically opposed to any attempt to correct or modify drive axle housings by bending or straightening. All damaged drive axle housings should be replaced.

WARNING

Do not bend or straighten damaged drive axle housings. Any bending or straightening process may result in misalignment or weakening of the axle housing and cause component damage and result in serious personal injury.

Removing Dri-Loc® Fasteners

If it is difficult to remove fasteners from components, the strength of Dri-Loc®, Rockwell adhesive or Loctite® 277 can be decreased by heating. Use the following procedure:

1. Heat the fastener for three to five seconds **only** and try to loosen the fastener with a wrench. **Do not** use an impact wrench to loosen the fastener or hit the fastener with a hammer.

CAUTION

Do not exceed 350°F (177°C) maximum. Heating must be done slowly to prevent thermal stresses in the other components.

2. Repeat step 1 until the fastener can be removed.

Section 4 General Information

Installing Fasteners with Pre-Applied Adhesive, Rockwell Liquid Adhesive 2297-C-7049, Loctite® 680 Liquid Adhesive or Equivalent

Installing New Fasteners with Pre-applied Adhesive Patches



WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

1. Clean the oil and dirt from threaded holes. Use a wire brush. There is no other special cleaning required.



CAUTION

Do not apply adhesives or sealants on new fasteners with pre-applied adhesive patches or inside closed threaded holes. If other adhesives or sealants are used, the new adhesive will not function correctly.

2. Assemble parts using the new pre-applied adhesive fasteners.

NOTE:

There is no drying time required for fasteners with pre-applied adhesive.

3. Tighten the fasteners to the required torque value for that size fastener.

Installing Original or Used Fasteners Using Rockwell Liquid Adhesive 2297-C-7049 or Loctite® 680 or Equivalent

1. Clean the oil, dirt and old adhesive from all threads and threaded holes. Use a wire brush.
2. Apply four or five drops of Rockwell Liquid Adhesive, Loctite® 680 or equivalent inside each threaded hole or bore ONLY. Make sure the adhesive is applied inside to the bore threads. **Figure 43.**



CAUTION

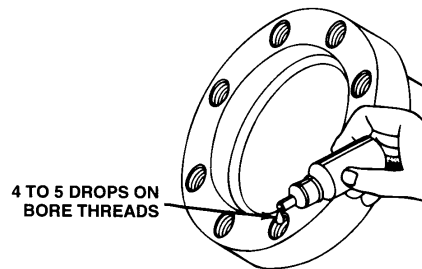
Do not apply adhesive directly to the fastener threads. Air pressure in a closed hole will push the adhesive out and away from mating surfaces as the fastener is installed.

3. Tighten the fasteners to the required torque value for that size fastener.

NOTE:

There is no drying time required for Rockwell Liquid Adhesive 2297-C-7049, Loctite® 680 or equivalent.

Figure 43

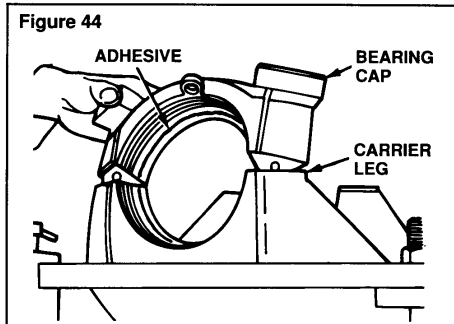


Section 4 General Information

Application of Rockwell Adhesive 2297-T-4180 in Bearing Bores for the Differential

- Use adhesive 2297-T-4180 for all axles.
1. Clean the oil and dirt from outer diameters of bearing cups and bearing bores in the carrier and bearing caps. There is no special cleaning required.
 2. Apply axle lubricant to the bearing cones and the inner diameters of the bearing cups of the main differential. **Do not** get oil on the outer diameter of the bearing cup and **Do not** permit oil to drip on the bearing bores.
 3. Apply a single continuous bead of the adhesive to the bearing bores in the carrier and bearing caps. Apply the adhesive 360° around the smooth, ground surfaces only. **Do not** place adhesive on threaded areas. **Figure 44.**

Figure 44



NOTE:

Rockwell adhesive 2297-T-4180 will become hard (dry) in approximately two hours. The following two steps of the procedure must be done in two hours from the time the adhesive was applied. If two hours have passed since application, clean the adhesive from the parts again and apply new adhesive.

4. Install the main differential assembly, bearing cups and bearing caps into the carrier. Use the normal procedure, refer to page 44.
5. Adjust preload of the differential bearings, backlash and tooth contact patterns of the gear set as required using the normal procedures. Refer to pages 45-54.

Application of Three Bond 1216 or Equivalent Silicone Gasket Material

⚠ WARNING

Small amounts of acid vapor are present when applying silicone gasket material. To prevent possible serious personal injury, make sure there is good ventilation in the work area. If the silicone gasket material gets in your eyes, flush your eyes with water for 15 minutes. Have your eyes checked by a doctor.

NOTE:

The following silicone gasket products or equivalent are available in 3 oz (85 gram) tubes and can be used for Rockwell components:

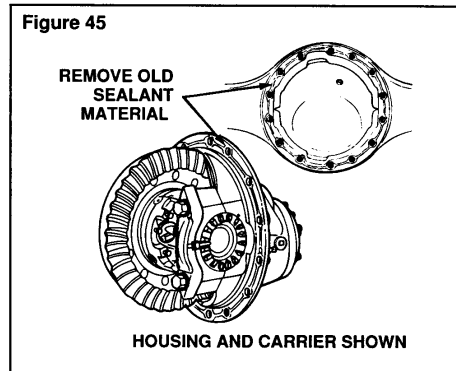
- Three Bond RTV No. TB 1216 (Grey) — Rockwell Part Number 2297-Z-7098
- Loctite® Ultra Grey RTV No. 5699 — Rockwell Part Number 2297-A-7021

Also available in 120 oz (3.4 kg) cartridges:

- Three Bond RTV1216 (Grey) — Rockwell Part Number 2297-A-7051

1. Remove all old gasket material from both surfaces. **Figure 45.**
2. Clean the surfaces where silicone gasket material will be applied. Remove all oil, grease, dirt and moisture without damaging the mating surfaces. **Figure 45.**

Figure 45



Section 4 General Information

3. Dry both surfaces.

CAUTION

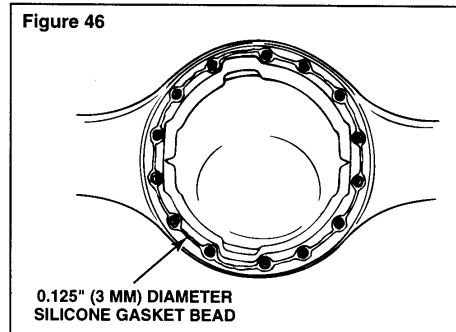
The amount of silicone gasket material applied must not exceed 0.125 inch (3 mm) diameter bead. Too much gasket material can block lubrication passages and result in damage to the components.

4. Apply 0.125 inch (3 mm) diameter continuous bead of the silicone gasket material around one surface. Also apply the gasket material around the edge of all fastener holes on that surface. **Figure 46.**
5. Assemble the components immediately to permit the silicone gasket material to compress evenly between the parts. Tighten fasteners to the required torque value for that size fastener. There is not special procedure or additional torque value required. Refer to the Torque Chart on page 61.



6. Wait 20 minutes before filling the assembly with lubricant.

Figure 46

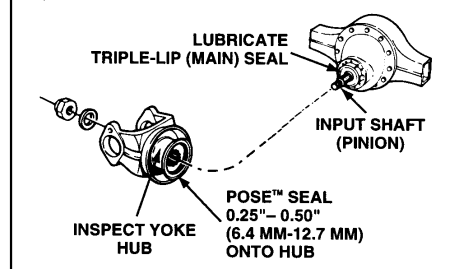


NOTE:

Rockwell adhesive products are available from Rockwell Heavy Vehicle Systems, Inc.

Installing Tight Fit Yokes and POSE™ Seal

Figure 47

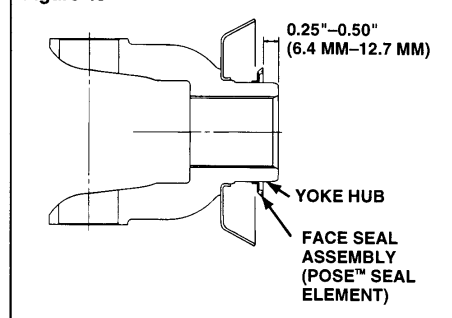


1. Apply the same lubricant used in the axle housing to the hub of the yoke or flange.
2. Inspect and make sure the lips of the POSE™ seal and the outer retainer of the triple-lip (main) seal are clean and free from dirt and particles that may cause lubricant leakage between the seals.
3. Install the POSE™ seal on the hub of the yoke or flange by hand. The lips of the seal must face toward the end of the hub (opposite shoulder). Slide the POSE™ seal on the hub until the lips are from 0.25 inch to 0.50 inch (6.4 mm-12.7 mm) from the end of the hub. **Do not install the POSE™ seal against the shoulder.** **Figure 48.**

NOTE:

The POSE™ seal will position itself correctly as the yoke or flange is pressed on the shaft.

Figure 48



Section 4 General Information

3. Dry both surfaces.

CAUTION

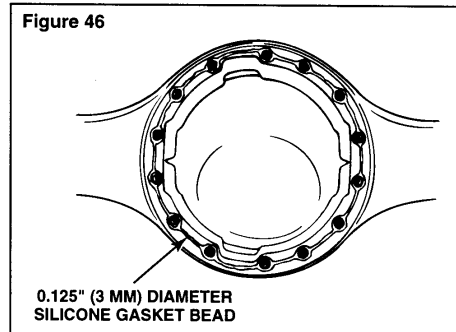
The amount of silicone gasket material applied must not exceed 0.125 inch (3 mm) diameter bead. Too much gasket material can block lubrication passages and result in damage to the components.

4. Apply 0.125 inch (3 mm) diameter continuous bead of the silicone gasket material around one surface. Also apply the gasket material around the edge of all fastener holes on that surface. **Figure 46.**
5. Assemble the components immediately to permit the silicone gasket material to compress evenly between the parts. Tighten fasteners to the required torque value for that size fastener. There is not special procedure or additional torque value required. Refer to the Torque Chart on page 61.



6. Wait 20 minutes before filling the assembly with lubricant.

Figure 46

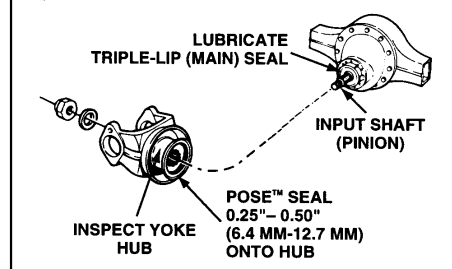


NOTE:

Rockwell adhesive products are available from Rockwell Heavy Vehicle Systems, Inc.

Installing Tight Fit Yokes and POSE™ Seal

Figure 47

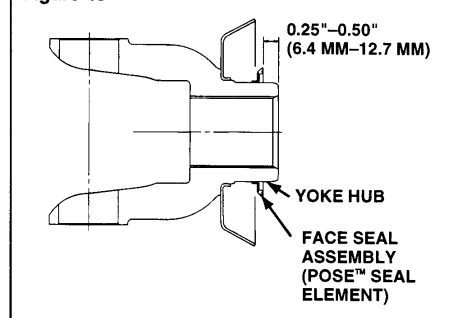


1. Apply the same lubricant used in the axle housing to the hub of the yoke or flange.
2. Inspect and make sure the lips of the POSE™ seal and the outer retainer of the triple-lip (main) seal are clean and free from dirt and particles that may cause lubricant leakage between the seals.
3. Install the POSE™ seal on the hub of the yoke or flange by hand. The lips of the seal must face toward the end of the hub (opposite shoulder). Slide the POSE™ seal on the hub until the lips are from 0.25 inch to 0.50 inch (6.4 mm-12.7 mm) from the end of the hub. **Do not install the POSE™ seal against the shoulder.** **Figure 48.**

NOTE:

The POSE™ seal will position itself correctly as the yoke or flange is pressed on the shaft.

Figure 48



Section 4

General Information

4. Before you install the yoke or flange on the shaft, again apply the same lubricant used in the axle housing to the hub.
5. Install the yoke or flange using the correct procedure.

NOTE:

The yoke must be completely seated before tightening pinion nut to the input shaft.

General Yoke and U-Joint Reassembly

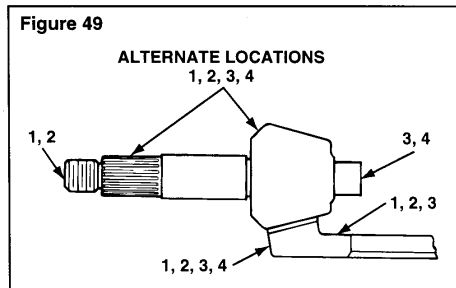
Install the end yoke hub capscrews by hand after seating the U-joint. Tighten the capscrews according to manufacturer's torque specifications.

Gear Set Information (Drive Pinion and Ring Gear Marks)

NOTE:

Read the following information before installing a new gear set in the carrier. Always inspect the gear set for correct marks to make sure the gears are a matched set.

The location of the marks are shown in Figure 49.



1. Part Number

a. Examples of gear set part numbers:

- Conventional ring gear, 36786.
- Conventional drive pinion, 36787.
- Generoid ring gear, 36786 K or 36786 K2.
- Generoid drive pinion, 36787 K or 36787 K2.

NOTE:

The last digit in part numbers for Generoid gears is a letter or letter and number.

b. Location on Drive Pinion: End at threads.

c. Location on Ring Gear: Front face or outer diameter.

2. Tooth Combination Number

a. Example of a tooth combination number:
5-37.

NOTE:

A 5-37 gear set has a 5-tooth drive pinion and a 37-tooth ring gear.

b. Location on Drive Pinion: End at threads.

c. Location on Ring Gear: Front face or outer diameter.

3. Gear Set Match Number

Rockwell drive pinions and ring gears are available only as matched sets. Both gears of a set have a match number.

a. Example of a gear set match number:
M29.

NOTE:

A gear set match number has any combination of a number or letter and number.

b. Location on Drive Pinion: End of gear head.

c. Location on Ring Gear: Front face or outer diameter.

Section 4

General Information

4. Pinion Cone Variation Number

NOTE:

The pinion cone variation number is not used when inspecting for a matched gear set. The number is used when you adjust the depth of the pinion in the carrier. Refer to the procedure for adjusting the shim pack thickness under the pinion cage on pages 36-38.

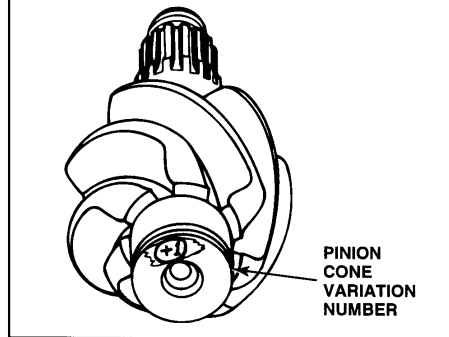
- a. Examples — refer to **Figure 50**.

Pinion cone variation numbers:

- PC+3 • +2 • +0.01 mm
- PC-5 • -1 • -0.02 mm

- b. **Location on Gear Set:** End of pinion gear head or outer diameter of ring gear.

Figure 50



Section 5 Assembly

Assemble the Drive Pinion, Bearings and Bearing Cage



WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

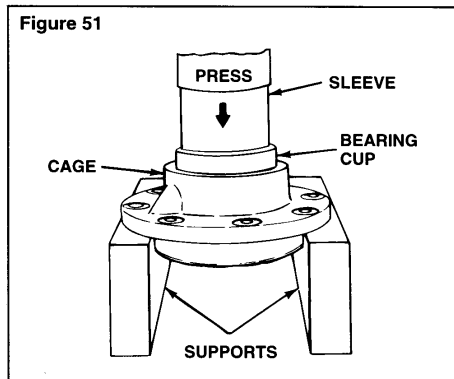


WARNING

Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

1. Place the bearing cage in a press. Figure 51.

Figure 51



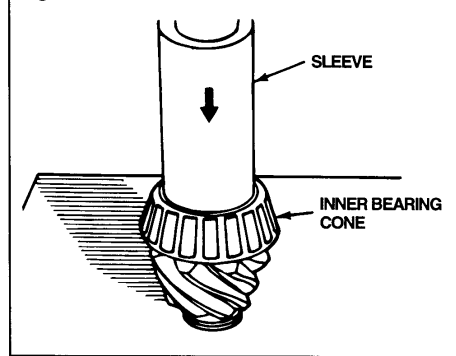
2. Support the bearing cage with metal or wood blocks.
3. Press the bearing cup into the bore of bearing cage until cup is flat against bottom of bore. Use a sleeve of the correct size to install bearing cup. Figure 51.

NOTE:

Use the same procedure for both bearing cups.

4. Place the drive pinion in a press, gear head (teeth) toward the bottom. Figure 52.

Figure 52



5. Press the inner bearing cone on the shaft of the drive pinion until the cone is flat against the gear head. Use a sleeve of the correct size against the bearing inner race.

NOTE:

Spigot bearings are usually fastened to the drive pinion with a snap ring. Some are fastened with a peening tool, and some are a two-piece bearing assembly with the inner race pressed on the nose of the pinion and the outer race pressed into its bore in the carrier. Use the following procedure to install the spigot bearing, then continue with steps 6-9 on page 31.

Section 5 Assembly

Installing the One-Piece Spigot Bearing on the Drive Pinion with Snap Ring

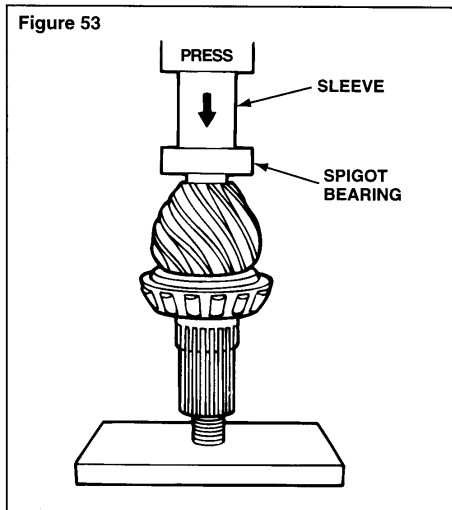
NOTE:

This procedure applies to all axles except:

- *Some 160 Series single axles may use snap rings.*
- *Some 160 and 180 Series rear rear tandem axles may use snap rings.*

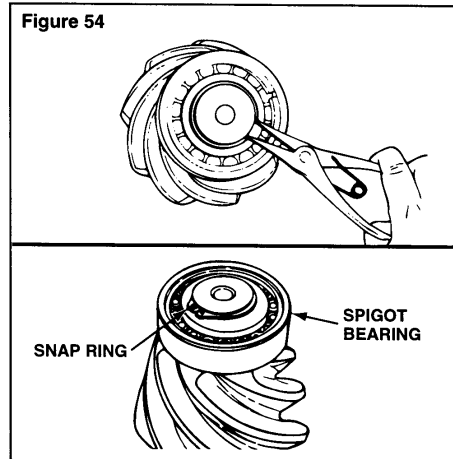
- Place the drive pinion in a press, gear head (teeth) toward the top. **Figure 53.**
- Press the spigot bearing on the end of drive pinion until the bearing is flat against the gear head. Use a sleeve of the correct size against the bearing inner race. **Figure 53.**

Figure 53



- Install the snap ring* into groove in end of drive pinion with snap ring pliers. **Figure 54.**

Figure 54



Staking the One-Piece Spigot Bearing on the Drive Pinion (Without Snap Ring)

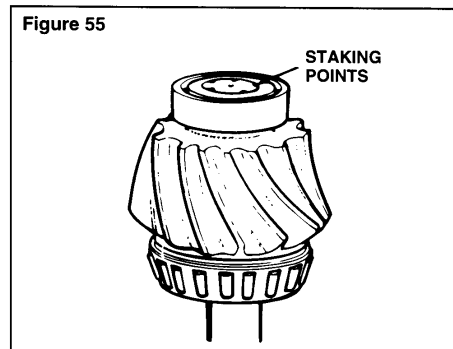
NOTE:

This procedure applies to some 180 Series rear rear tandem axles with existing snap ring components.

Specification

- Apply 6,614 lb. (3,000 kg) force on a 0.375-inch (10 mm) ball.
- Stake the end of drive pinion at a minimum of five points. **Figure 55.**

Figure 55



Section 5 Assembly

When using a staking tool and press (Figure 56), calculate the force required on the tool as follows.

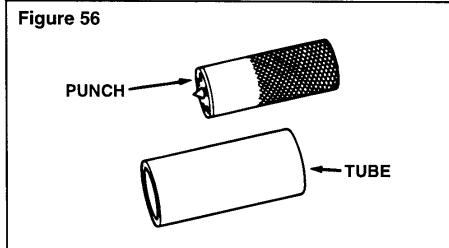
6,614 lb. (3,000 kg) x amount of balls in tool =
pounds or kilograms

Example

6,614 lb. x 3 balls = 19,842 pounds

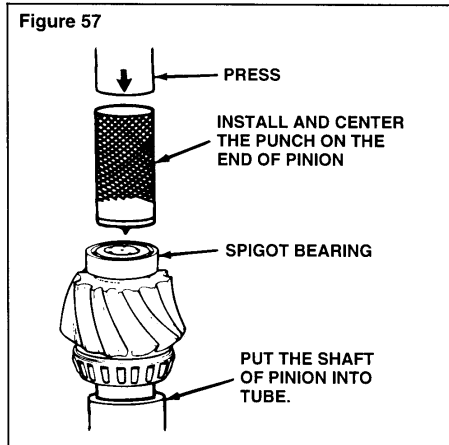
For information about the staking tool, contact your local Rockwell representative. Figure 56.

Figure 56



- Place the drive pinion and the tube of the staking tool in a press, spigot bearing toward the top. Figure 57.
- Calculate the amount of force that will be required on the staking tool. Refer to specification and example calculation.

Figure 57



- Place the punch of the staking tool over the end of the pinion and spigot bearing. Apply the required amount of force on the punch. Figure 57.

CAUTION

Do not align new points with grooves in end of drive pinion or in old points. If the new staked points are placed in the wrong areas, the spigot bearing will not be held correctly on the pinion shaft.

- Rotate the punch as many times as required for a minimum of five points. Repeat step c for each point.

NOTE:

If a three-ball stake tool is used, rotate the tool 180° (degrees).

Installing and Staking the Two-Piece Spigot Bearing on the Drive Pinion

NOTE:

This procedure applies to some 160 Series single rear axles and rear rear tandem axles. These axles may also use a one-piece spigot bearing with a snap ring retainer.

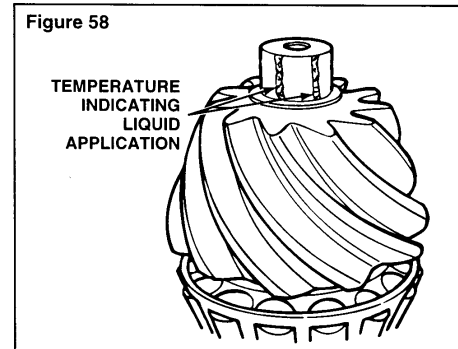
The inner race of two-piece spigot bearings may need to be staked in place on some R-160 series rear axles. Before you stake the pinion, you must heat the pinion stem to soften it.

NOTE:

Kent-Moore Kit J-39039 includes the staking tool, temperature indicating liquid, heating shield and plastigage needed for this job.

- Apply two stripes of temperature indicating liquid on the pinion stem from the top to the bottom. Figure 58. Apply a green stripe to indicate 400°F (205°C) and a blue stripe to indicate 500°F (260°C).

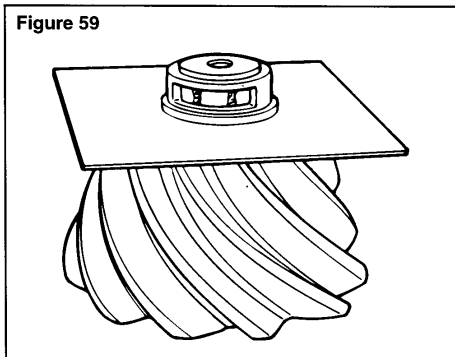
Figure 58



Section 5 Assembly

- b. Place the heating shield over the pinion stem so that you can see the temperature indicating liquid through the hole in the shield. **Figure 59.**

Figure 59



WARNING

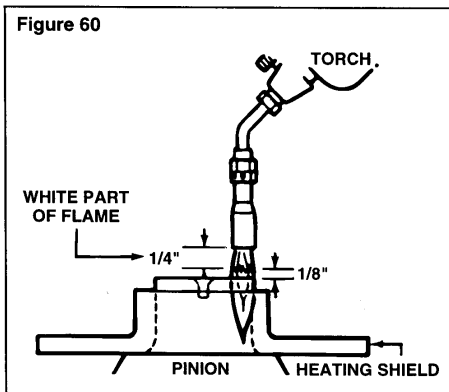
Always wear safe clothing, gloves and eye protection when working with a torch for heating parts to prevent serious personal injury during assembly.

CAUTION

Do not heat the pinion stem without the heat shield in place. Also, do not overheat the pinion stem or you will weaken the metal which can cause early failure. Correct heating will take approximately 25-35 seconds, depending on how hot the torch is.

- c. Light and adjust the torch until the white part of the flame is approximately 1/4 inch long. Keep the white part of the flame approximately 1/8 inch from the top of the stem. **Figure 60.** Move the flame around the outer diameter of the top of the pinion stem. The green temperature indicating liquid will turn black before the blue liquid does. Heat the stem until the blue liquid turns black at a point in the middle of the window.

Figure 60



- d. Remove the flame and the heat shield from the pinion. Let the pinion air cool for 10 minutes. Use a razor blade to remove the temperature indicating liquid.

CAUTION

Do not press or directly strike the new inner race in step e or damage to the bearing will result.

WARNING

Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

- e. Use a press, if available, or a brass hammer to install the new inner race. Use the old inner race as a sleeve. The face is completely seated when you cannot fit a 0.002-inch feeler gauge between the race and the pinion shoulder.

Section 5 Assembly

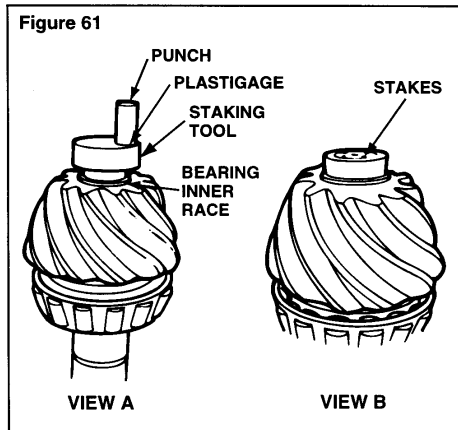
NOTE:

To hold the races in place, use a staking tool, instead of the old race, to start the new race on the stem. The old race can be used to completely seat the new race.

NOTE:

In step f, you do not need to use the plastigage for every stake. Use the plastigage until you are sure you are hitting the punch with the correct amount of force.

- f. Place the staking tool over the bearing race. Cut a one inch piece from the green plastigage strip and place in between the punch and the staking tool. **Figure 61 — View A.**

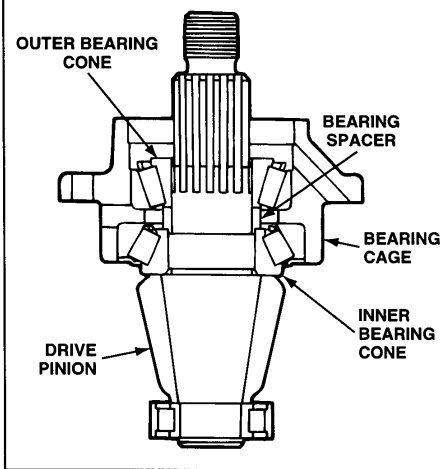


- g. Strike the punch with a two-three pound brass hammer to upset the end of the pinion stem. Then, remove the strip and measure its thickness against the gauge on the wrapper that the strip came in. The strip must not be less than 0.003 inch thick. This thickness indicates that you are using enough force when you hit the punch. If the strip is too thin, then you must hit the punch harder so the stake will hold the race in place. Rotate the tool and repeat this procedure until there are six evenly spaced stake marks around the stem. **Figure 61 — View B.**

- h. With a press or a soft mallet and sleeve, install the outer race and roller assembly into its bore in the carrier. Use a sleeve that is the same size as the outer race and press the bearing until it is squarely against the shoulder in the bottom of its bore.

6. Apply axle lubricant to the bearing cups and to the bearing cones in the cage.
7. Install the drive pinion into the bearing cage.
8. Install the bearing spacer or spacers on pinion shaft against the inner bearing cone. **Figure 62.**

Figure 62



NOTE:

The spacer or spacers control the preload adjustment of the drive pinion bearings.

9. Install the outer bearing cone on pinion shaft against the spacer. **Figure 62.**

NOTE:

DO NOT install pinion seal in bearing cage. Continue with adjusting preload of pinion bearings.

Section 5 Assembly

Adjusting Preload of Pinion Bearings

Specifications

- New pinion bearings — torque
— 5 to 45 lb-in (0.56-5.08 N•m) **T**
- Used pinion bearing in good condition — torque
— 10 to 30 lb-in (1.13-3.39 N•m) **T**

Press Method

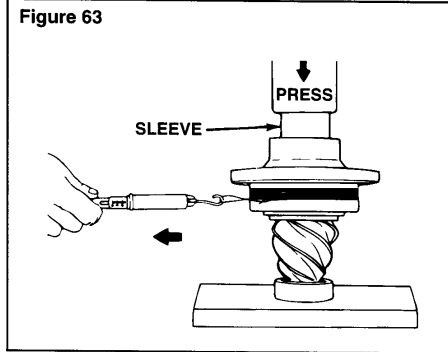
NOTE:

If a press is not available, or the press does not have a pressure gauge, use the yoke or flange method to adjust pinion bearing preload. Refer to page 33.

- Place the drive pinion and cage assembly in a press, gear head (teeth) toward the bottom.
- Install a sleeve of the correct size against the inner race of the outer bearing. **Figure 63.**
- Apply and hold the correct amount pressure to the pinion bearings. Refer to **Chart 1.**
As pressure is applied rotate the bearing cage several times so that bearings make normal contact.

- While pressure is held against the assembly, wind a cord around the bearing cage several times.

Figure 63



- Attach a spring scale to the end of the cord.
- Pull the cord with scale on a horizontal line.
As the bearing cage rotates, read the value indicated on scale. Write down and record the reading. **Figure 63.**

NOTE:

Do not read starting torque. Read only the torque value after the cage starts to rotate. Starting torque will give a false reading.

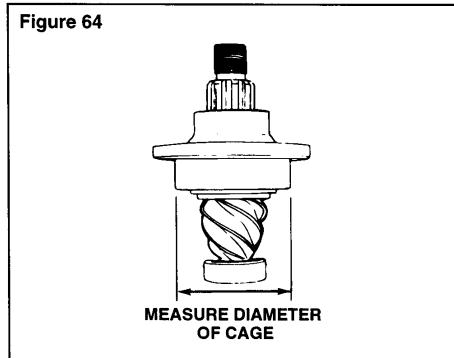
Chart 1

Thread Size of Pinion Shaft	Press Pressure Needed on Bearings for Correct Preload.		T Torque Value Needed on Pinion Nut for Correct Bearing Preload.	
	pounds/tons	(kg/metric tons)	lb-ft	(N•m)
7/8"-20	22,000/1	(9979/10)	200-275	(271-373)
1"-20	30,000/15	(13608/13.6)	300-400	(407-542)
1 1/4"-12	54,000/27	(24494/24.5)	700-900	(949-1220)
1 1/4"-18	54,000/27	(24494/24.5)	700-900	(949-1220)
1 1/2"-12	54,000/27	(24494/24.5)	800-1100	(1085-1491)
1 1/2"-18	54,000/27	(24494/24.5)	800-1100	(1085-1491)
1 3/4"-12	50,000/25	(22680/22.7)	900-1200	(1220-1627)
2"-12	50,000/25	(22680/22.7)	1200-1500	(1627-2034)

Section 5 Assembly

- g. Measure the diameter of bearing cage where the cord was wound. Measure in inches or centimeters. **Figure 64.**
- h. Divide the dimension in half to get the radius. Write down and record the radius dimension.

Figure 64



- i. Use the following procedure to calculate the bearing preload (torque).
 - Pounds Pulled x Radius (inches) = lb-in Preload
— Preload x 0.113 = N•m Preload
 - Kilograms Pulled x Radius (cm) = kg-cm Preload
— Preload x 0.098 = N•m Preload
- or**

Examples

- Reading from spring scale = 7.5 pounds (3.4 kg)
 - Diameter of bearing cage = 6.62 inches (16.80 cm)
 - Radius of bearing cage = 3.31 inches (8.40 cm)
- 7.50 lb. x 3.31 in. = 24.80 in-lb Preload
Preload x 0.113 = 2.800 N•m Preload
- or**
- 3.4 kg x 8.4 cm = 28.6 kg-cm Preload
Preload x 0.098 = 2.800 N•m Preload

- j. If the preload (torque) of pinion bearings is not within specifications, do the following procedure then repeat steps a through i.

To increase preload, install a thinner bearing spacer. To decrease preload, install a thicker bearing spacer.

- k. Inspect the bearing preload with the drive pinion and cage assembly installed in the carrier. Follow the procedures to adjust preload of pinion bearings, yoke or flange method.

Yoke or Flange Method

WARNING

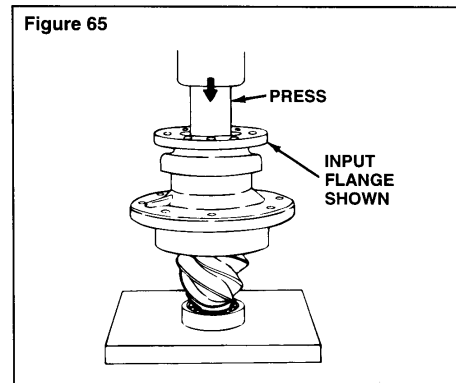
Observe all WARNINGS and CAUTIONS provided by the press manufacturer concerning press operation to avoid serious personal injury and possible damage to components during assembly and installation procedures.

- a. Install the input yoke or flange, nut and washer on the drive pinion. The yoke or flange **must** be seated against the outer bearing

NOTE:

Use a press to install the yoke or flange. Figure 65.

Figure 65



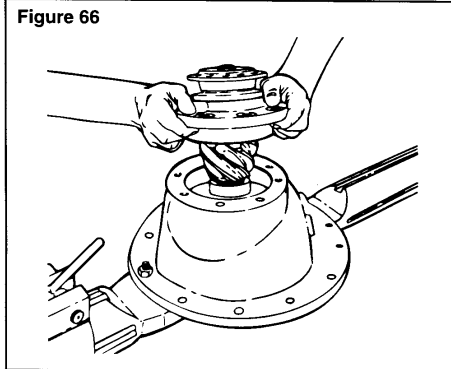
Section 5 Assembly

CAUTION

Do not install tight fit yokes or flanges on shafts using a hammer or mallet. A hammer or mallet will damage the yoke or flange.

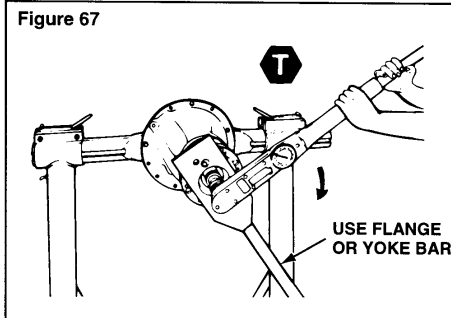
- b. Temporarily install the drive pinion and cage assembly in the carrier. Do not install shims under the bearing cage. **Figure 66.**


Figure 66



- c. Install the bearing cage to carrier capscrews. Washers are not required at this time. Tighten the capscrews by hand until snug.
- d. Fasten a yoke or flange bar to the input yoke or flange. The bar will hold the drive pinion in position when the nut is tightened. **Figure 67.**

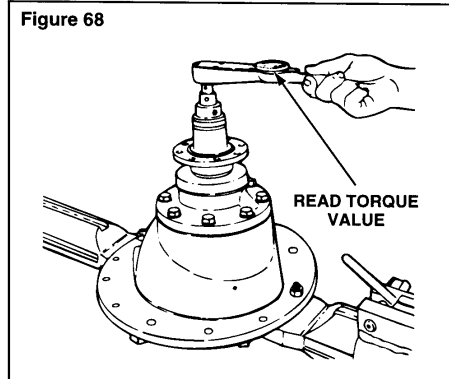
Figure 67



- e. Tighten the nut on drive pinion to the correct torque value. **Figure 67.** Refer to **Chart 1** on page 32. 

- f. Remove the yoke or flange bar.
- g. Attach a torque wrench on the drive pinion nut. Rotate the drive pinion and read the value indicated on torque wrench. **Figure 68.**

Figure 68

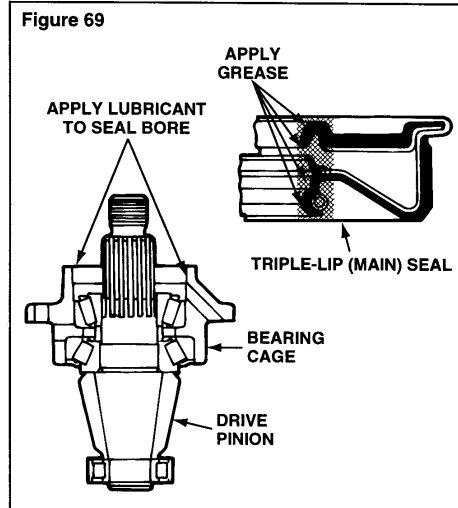


- h. If the preload (torque) of pinion bearings is not within specifications, remove the pinion and cage assembly from carrier. Do the following procedure then repeat steps **a** through **g**.
 - To **increase** preload, install a thinner bearing spacer.
 - To **decrease** preload, install a thicker bearing spacer.
10. After adjusting preload of pinion bearings, remove the drive pinion and bearing cage from carrier. Follow steps 1-5 on pages 12-13.

Section 5 Assembly

11. Install a new triple-lip seal as follows.

- a. Apply the same lubricant used in the axle housing to the outer surface of the seal and the seal bore in the bearing cage. **Figure 69.**

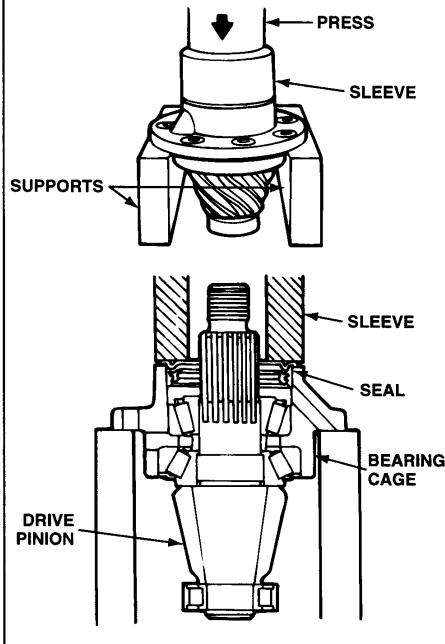


CAUTION

Make sure that the seal lips are clean and free from dirt and particles that will cause a leak between the yoke and the seal.

- b. Place the drive pinion and cage assembly in a press, seal bore toward the top.
- c. Press the seal into bearing cage until flange of seal is flat against the top of bearing cage. Use a sleeve or seal driver of the correct size that fits against the metal flange of seal. The diameter of the sleeve or driver **must** be larger than the diameter of the flange. **Figure 70.**

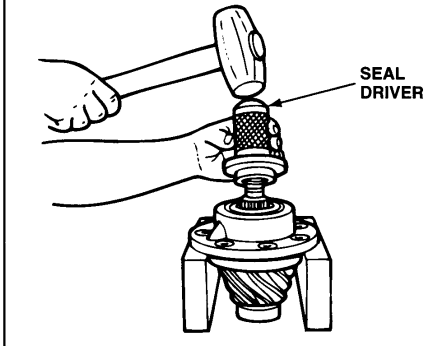
Figure 70



NOTE:

*If a press is not available, use a mallet and the sleeve or driver to install the seal. **Figure 71.***

Figure 71

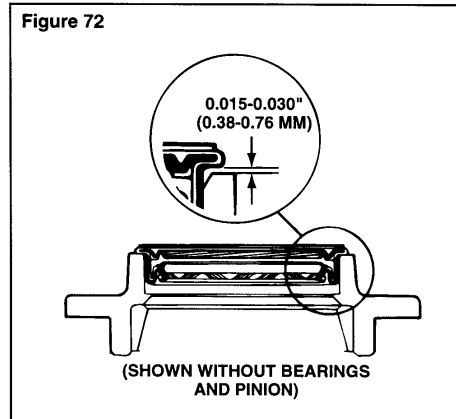


Section 5 Assembly

WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

- d. After the triple-lip seal is installed, a gap of approximately 0.015 to 0.030 inch (0.38-0.76 mm) between the flange and bearing cage is normal. **Figure 72.**

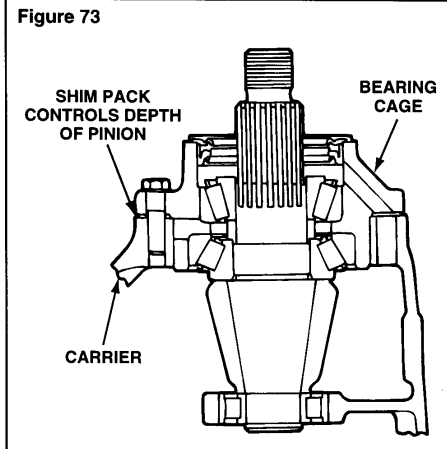


Inspect the gap with a feeler gauge at several points around the seal. The gap must be within 0.015 to 0.030 inch (0.38-0.76 mm). The difference between the largest and smallest gap measurement **must not** exceed 0.010 inch (0.254 mm).

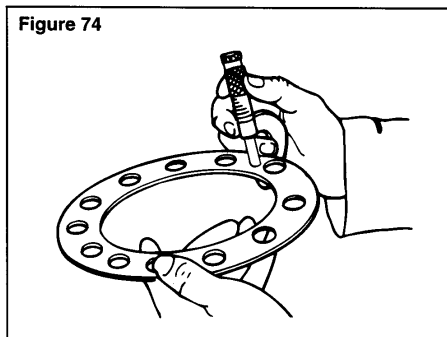
Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)

NOTE:

Use this procedure if a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted. Figure 73.



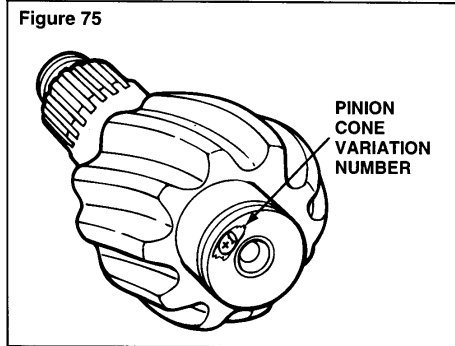
1. Measure the thickness of the old shim pack that was removed from under the pinion cage with a micrometer. Record the measurement for use later. **Figure 74.**



Section 5 Assembly

2. Look at the pinion cone ("PC") variation number on the old drive pinion that is being replaced. Refer to Gear Set Information, step 4 on page 26 for examples and location of the number. Record the number for later use. If ("PC") variation number cannot be located, assemble gear set with shim pack thickness found in step 1 on page 36.
Figure 75.

Figure 75



NOTE:

The pinion cone number can be either 100ths of a millimeter or 1,000ths of an inch. Refer to the following examples.

PC +3, PC - 3, +3 or -3 = 0.003 inch

PC +.03, PC -0.03 mm, +0.03 mm or -0.03 = 0.03 mm

To change millimeters to inches — millimeters x 0.039

To change inches to millimeters — inches x 25.40

3. If the old pinion cone number is a plus (+) number, subtract the number from the old shim pack thickness that was measured in step 2.
4. If the old pinion cone number is a minus (-) number, add the number to the old shim pack thickness that was measured in step 2.

NOTE:

The value calculated in step 3 or 4 is the thickness of the standard shim pack, without a variation.

5. Look at the pinion cone ("PC") variation number on the new drive pinion that will be installed. Record the number for later use.
6. If the new pinion cone number is a plus (+) number, add the number to the standard shim pack thickness that was calculated in step 3 or 4.
7. If the new pinion cone number is a minus (-) number, subtract the number from the standard shim pack thickness that was calculated in step 3 or 4.

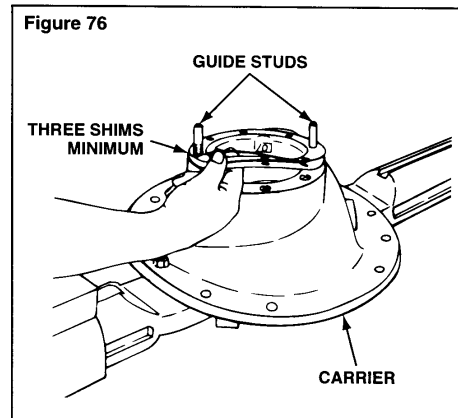
Section 5 Assembly

Installing the Drive Pinion, Bearing Cage and Shim Pack into the Carrier

NOTE:

If a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted, calculate the thickness of the shim pack. Refer to the procedure "Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)" on page 36.

1. Select the correct shim pack between the bearing cage and carrier. **Figure 76.**
2. Apply Loctite® 518 Gasket Eliminator to face of carrier.
3. Align the oil slots in the shims with oil slots in the bearing cage and carrier. The use of guide studs will help align the shims. **Figure 76.**



NOTE:

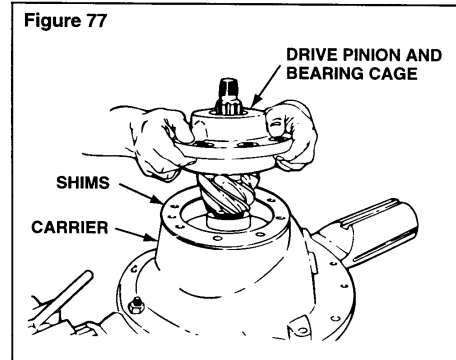
If the pack is made from different thickness shims, install the thinnest shims on both sides of the pack for maximum sealing.

4. Apply Loctite® 518 Gasket Eliminator to top of shim pack.

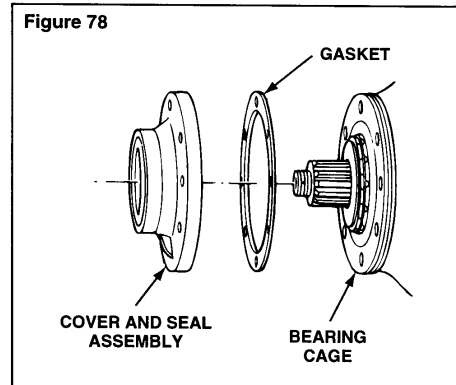
WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

5. Install the drive pinion and bearing cage into the carrier. If necessary, use a rubber, plastic or leather mallet to hit the assembly into position. **Figure 77.**




6. If used, install the cover* and seal assembly and gasket* over the bearing cage. **Figure 78.**

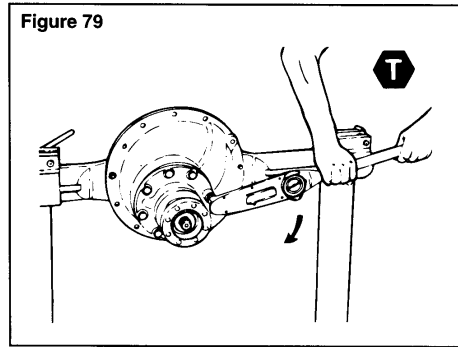


7. Align the oil slots in the cover and gasket with oil slot in the bearing cage.

Section 5 Assembly

8. Install the bearing cage to carrier capscrews and washers. Tighten capscrews to correct torque value. Refer to the Torque Chart on page 61.

Figure 79. 



Installing Tight Fit Yokes and POSE™ Seal

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that will cause a leak between the yoke and the seal.

CAUTION

Do not install tight fit yokes on shafts using a hammer or mallet. Using a hammer or mallet can damage the yoke.

1. Apply axle lubricant on the yoke seal.
2. Inspect all surfaces of the yoke hub for damage.

If carrier uses a POSE™ seal element, install a new POSE™ seal as follows:

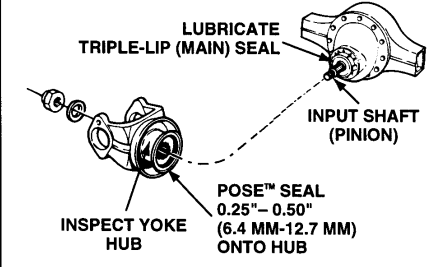
- a. Lightly lubricate yoke journal with same lubricant used in the axle housing.

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that can cause a leak between the yoke and the POSE™ seal.

- b. Partially install the POSE™ seal onto the yoke to 1/4 inch-1/2 inch as shown in **Figure 80**.

Figure 80



NOTE:

DO NOT install POSE™ seal all the way against the yoke shoulder. This seal is designed to position itself as yoke is installed.

- c. Before installing the yoke onto the drive pinion, lubricate the yoke again with the same lubricant used in the axle housing.
3. Slide the yoke over the input shaft pinion. Align the yoke splines with the shaft splines.

CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. Using a hammer or mallet can damage the yoke or flange.

4. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing **before** the nut is torqued to specifications.
5. Install the drive pinion nut on the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications.


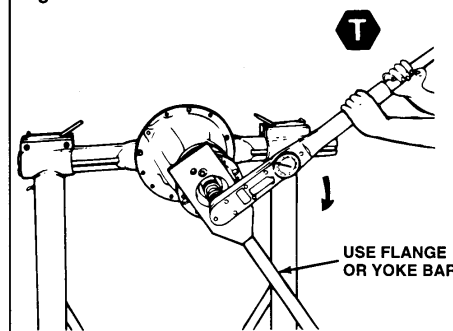
Figure 81. Refer to page 61. 

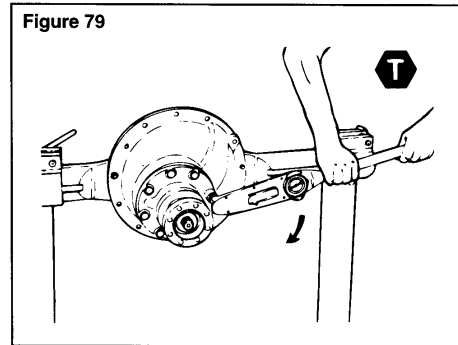
Figure 81



Section 5 Assembly

8. Install the bearing cage to carrier capscrows and washers. Tighten capscrows to correct torque value. Refer to the Torque Chart on page 61.

Figure 79. 



Installing Tight Fit Yokes and POSE™ Seal

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that will cause a leak between the yoke and the seal.

CAUTION

Do not install tight fit yokes on shafts using a hammer or mallet. Using a hammer or mallet can damage the yoke.

1. Apply axle lubricant on the yoke seal.
2. Inspect all surfaces of the yoke hub for damage.

If carrier uses a POSE™ seal element, install a new POSE™ seal as follows:

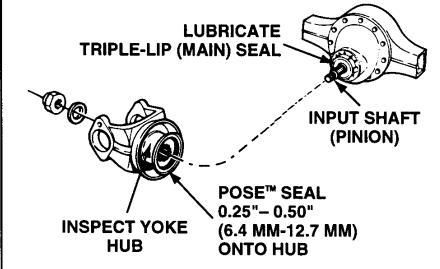
- a. Lightly lubricate yoke journal with same lubricant used in the axle housing.

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that can cause a leak between the yoke and the POSE™ seal.

- b. Partially install the POSE™ seal onto the yoke to 1/4 inch-1/2 inch as shown in **Figure 80**.

Figure 80



NOTE:

DO NOT install POSE™ seal all the way against the yoke shoulder. This seal is designed to position itself as yoke is installed.

- c. Before installing the yoke onto the drive pinion, lubricate the yoke again with the same lubricant used in the axle housing.
3. Slide the yoke over the input shaft pinion. Align the yoke splines with the shaft splines.

CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. Using a hammer or mallet can damage the yoke or flange.

4. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing **before** the nut is torqued to specifications.
5. Install the drive pinion nut on the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications.


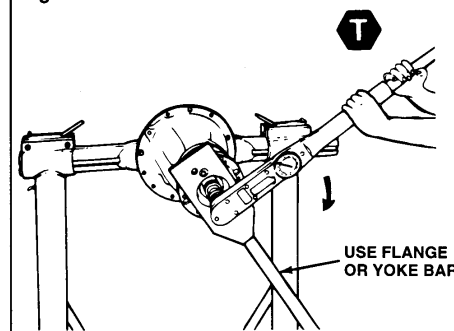
Figure 81. Refer to page 61. 

Figure 81



Section 5 Assembly

Assemble the Main Differential and Ring Gear Assembly



CAUTION

Do not press a cold ring gear on the flange case half. A cold ring gear will damage the case half because of the tight fit. Metal particles between the parts will cause gear runout that exceeds the Rockwell specification of 0.008 inch (0.200 mm).

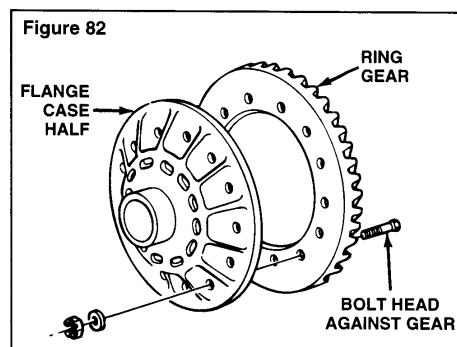
1. Expand the ring gear by heating the gear in a tank of water to a temperature of 160°F to 180°F (71°C-82°C) for 10 to 15 minutes.



WARNING

Wear safe clothing and gloves for protection from injury when working with the hot ring gear.

2. Safely lift the ring gear from the tank of water using a lifting tool.
3. Install the ring gear on the flange case half immediately after the gear is heated. If the ring gear does not fit easily on the case half, heat the gear again. Repeat step 1.
4. Align fastener holes of the ring gear and flange case half. Rotate the ring gear as needed.
5. If rivets were used to hold the ring gear to the flange case half, replace them with bolts, nuts and washers.
6. Install the bolts, nuts and washers that hold the ring gear to the flange case half. Install the bolts from the gear side of the assembly. The bolt heads **must** be against the ring gear. **Figure 82.**




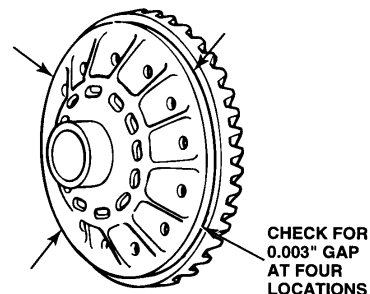
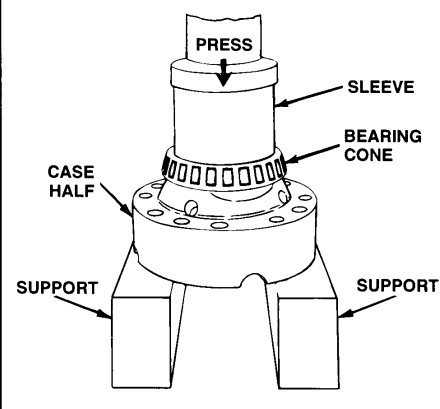
7. Tighten the bolts and nuts to the correct torque value. Refer to the Torque Chart on page 61. 
8. Inspect for gaps between the back surface of the ring gear and the case flange after the bolts are installed. Use an 0.003 inch (0.080 mm) feeler gauge and inspect at four points around the assembly. **Figure 83.**

Figure 83



9. Inspect the flange case half and ring gear for the problem that causes the gap. Repair or replace parts that do not meet specifications.
10. Assemble the repaired or replaced ring gear on the flange case half. Repeat the Main Differential and Ring Gear Assembly procedure on this page.
11. Install the bearing cones on both of the case halves. Use a press and sleeve of the correct size. **Figure 84.**

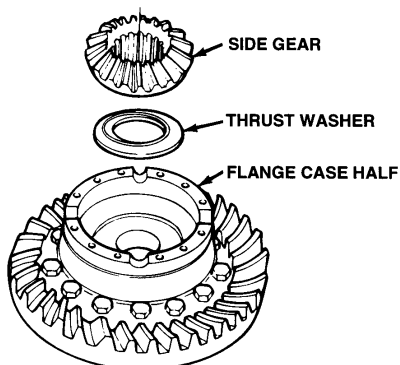
Figure 84



Section 5 Assembly

12. Apply axle lubricant on the inside surfaces of both case halves, spider (cross), thrust washers, side gears and differential pinions.
13. Place the flange case half on a bench, ring gear teeth toward top.
14. Install one thrust washer and side gear into the flange case half. **Figure 85.**

Figure 85

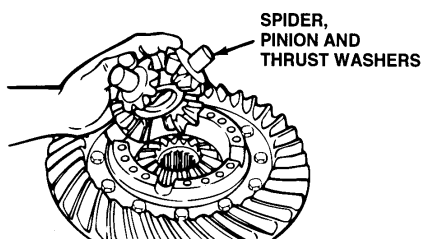


CAUTION

The side gears in some carrier models have hubs of different lengths. Install the correct length side gear into the flange case half.

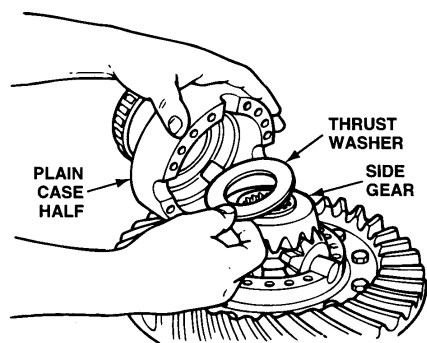
15. Install the spider (cross), differential pinions and thrust washers into the flange case half. **Figure 86.**

Figure 86



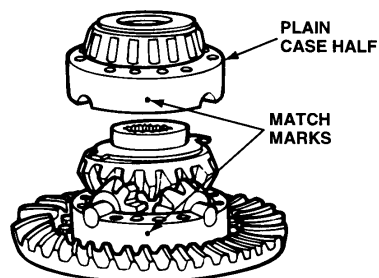
16. Install the second side gear and thrust washer over spider and differential pinions. **Figure 87.**

Figure 87



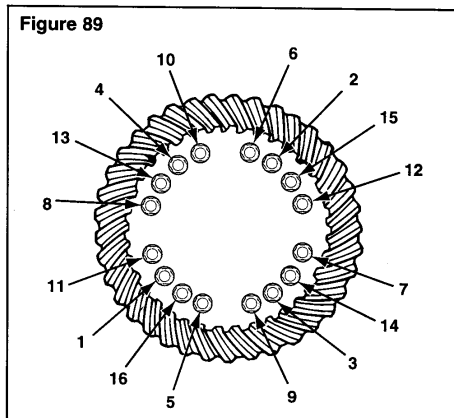
17. Place the plain half of the differential case over the flange half and gears. Rotate the plain half as needed to align the match marks. **Figures 87 and 88.**

Figure 88



Section 5 Assembly

18. Install Dri-Loc fasteners into the case halves. Refer to the procedures on page 23 and the following steps **a** and **b**.
- a. Install four capscrews and washers or bolts, nuts* and washers* into the case halves. The distance between the fasteners **must** be equal. Tighten the fasteners to the correct torque value in a progressive criss-cross pattern opposite each other. Refer to **Figure 89** and the Torque Chart on page 61. **1**



- b. Install the other fasteners into the case halves. Tighten the fasteners to the correct torque value. Refer to the Torque Chart on page 61. **1**

19. Inspect the rotating resistance of the differential gears. Use the following procedure.

Inspecting the Rotating Resistance of the Differential Gears

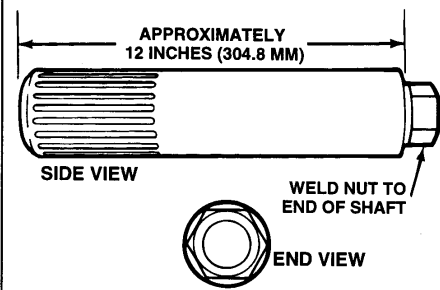
Specification

- 50 lb-ft (67.8 N•m) maximum torque applied to one side gear. **1**

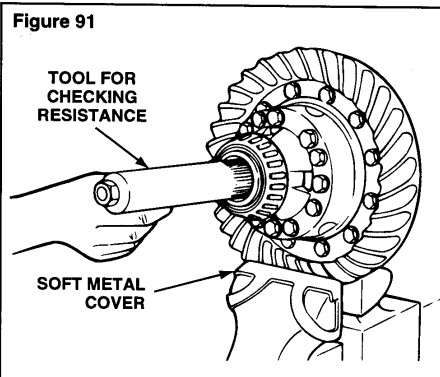
NOTE:

Make a tool for inspecting the rotating resistance of the differential gears. The tool can be made from an axle shaft that matches the spline size of the differential side gear. Refer to Figures 90 and 91.

Figure 90



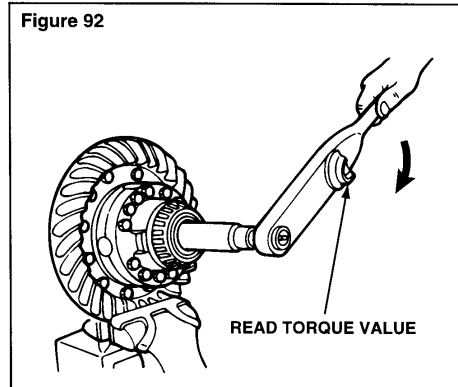
1. Install soft metal covers over vise jaws to protect the ring gear. **Figure 91**.



2. Place the differential and ring gear assembly in the vise and close the vise jaws.
3. Install the tool into the differential until the splines of the tool and one side gear are engaged. **Figure 91**.

Section 5 Assembly

- Engage a torque wrench to the nut of the tool and rotate the differential gears. As the differential gears rotate, read the value indicated on the torque wrench. **Figure 92.**

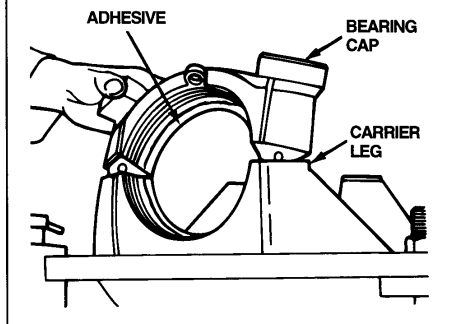


- If the torque value exceeds the specification, disassemble the differential gears from the case halves.
- Inspect the case halves, spider, gears and thrust washers for the problem that causes the torque value to exceed the specification. Repair or replace parts.
- After all the differential assembly parts are repaired or replaced, assemble the parts and repeat steps 1 through 7.

Install the Differential and Ring Gear Assembly

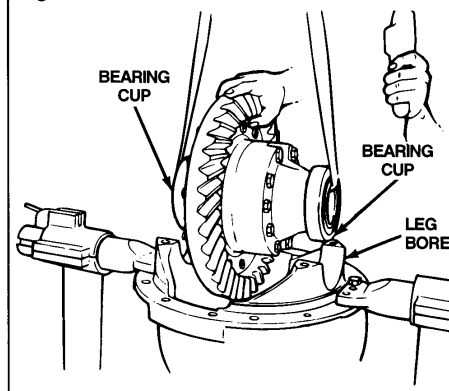
- Clean and dry the bearing cups and bores of the carrier legs and bearing caps.
- Apply axle lubricant on the inner diameter of the bearing cups and on both bearing cones that are assembled on the case halves.
- Apply Rockwell Adhesive into the bearing bores of the carrier legs and bearing caps. Make certain not to allow adhesive to contact adjusting ring threads. Refer to the procedure on page 23. **Figure 93.**

Figure 93



- Install the bearing cups over the bearing cones that are assembled on the case halves. **Figure 94.**
- Safely lift the differential and ring gear assembly and install into the carrier. The bearing cups **must** be flat against the bores between the carrier legs. **Figure 94.**

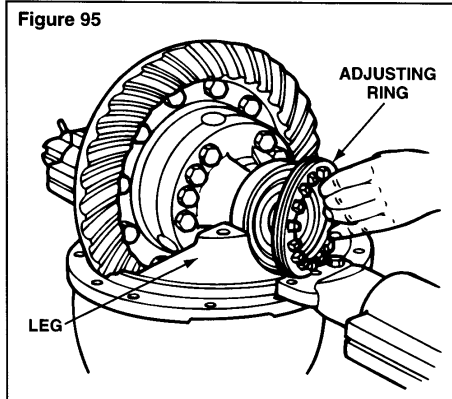
Figure 94



- Install both of the bearing adjusting rings into position between the carrier legs. Turn each adjusting ring hand-tight against the bearing cup. **Figure 95.**

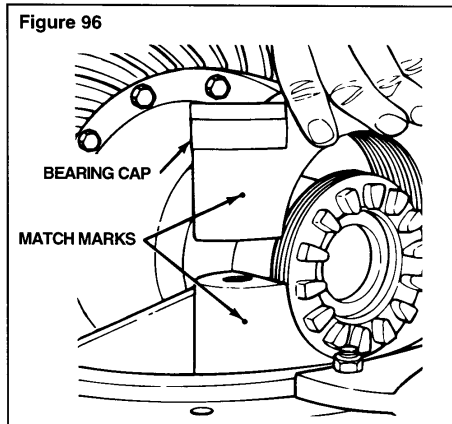
Section 5 Assembly

Figure 95



7. Install the bearing caps over the bearings and adjusting rings in the correct location as marked before removal. **Figure 96.**

Figure 96




WARNING

Do not hit steel parts with a steel hammer during removal and disassembly procedures. Striking parts with a hammer can cause the parts to break and result in serious personal injury.

8. Seat each bearing cap with a light leather, plastic or rubber mallet. The caps **must** fit easily against the bearings, adjusting rings and carrier. **Do not force the bearing caps into position.**

CAUTION

If bearing caps are not installed in the correct original locations, the bores and threads in caps will not match the carrier. Assembling mismatched caps into the carrier can result in carrier damage after reassembly to axle and during vehicle operation. Do not force the bearing caps into unmatched bore locations in the carrier.


9. If bearing caps do not correctly fit into position, inspect the alignment of match marks between caps and carrier. Remove the caps and repeat steps 6-8.
10. Install the capscrews and washers that hold bearing caps to the carrier. Tighten the capscrews by hand four to six turns, then tighten the capscrews to the correct torque value. Refer to the Torque Chart on page 61. 

NOTE:

Do not install the cotter keys, pins or lock plates that hold the bearing adjusting rings in position. Continue by adjusting the preload of differential bearings, adjust backlash of the hypoid gear and inspect tooth contact patterns.

Adjust Preload of Differential Bearings

Specifications

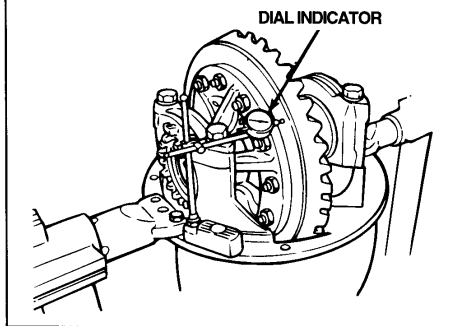
- Preload of differential bearings (all carrier models)
 - 15 to 35 lb-in (1.7-3.9 N·m) torque. 
- Expansion between bearing caps (leg spread)
 - R-140, R-155 and R-160 carrier models: 0.002 to 0.009 inch (0.050-0.229 mm)
 - R, S, U and W 120 series and most (check latest specifications) other carrier models: 0.006 to 0.013 inch (0.150-0.330 mm)

Section 5 Assembly

Method 1

1. Attach a dial indicator on the mounting flange of the carrier.
2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear. **Figure 97.**

Figure 97

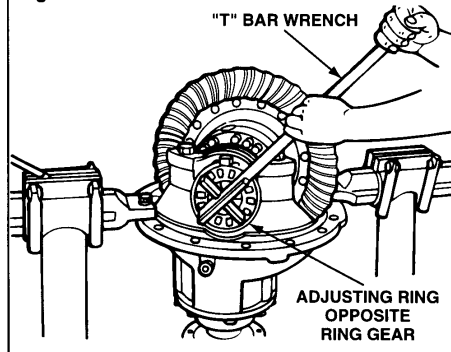


CAUTION

*When you turn the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A "T" bar wrench can be used for this purpose. If the tool does not correctly fit into the notches, damage to the lugs will occur. **Figure 98.***

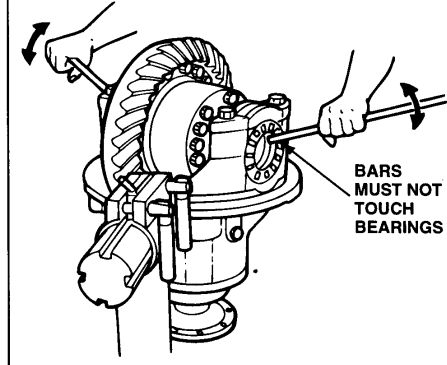
3. Loosen the bearing adjusting ring that is opposite the ring gear so that a small amount of end play shows on the dial indicator. **Figure 98.** Move the differential and ring gear to the left and right with pry bars while you read the dial indicator. Use the following step **a** or **b**.

Figure 98



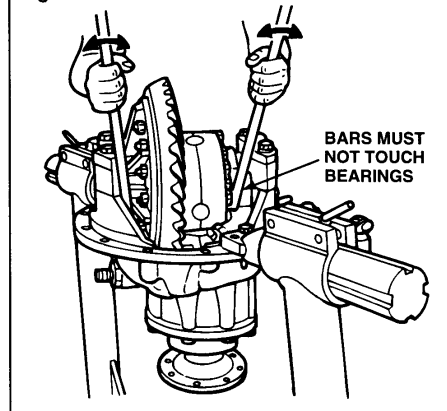
- a. Use two pry bars that fit between the bearing adjusting rings and ends of the differential case. The pry bars **must not** touch the differential bearings. **Figure 99.**

Figure 99



- b. Use two pry bars between the differential case or ring gear and the carrier at locations other than described in step **a**. The pry bars **must not** touch the differential bearings. **Figure 100.**

Figure 100



4. Tighten the same bearing adjusting ring so that no end play shows on the dial indicator. Move the differential and ring gear to the left and right as needed. Repeat step **a** or **b**.

Section 5 Assembly

5. Tighten each bearing adjusting ring one notch from the zero end play measured in step 4.
6. Continue by checking runout of the ring gear.

Method 2

A second method of inspecting preload is to measure the expansion between the bearing caps (leg spread) after the adjusting rings are tightened. Use the following procedure.

1. Turn both adjusting rings hand tight against the differential bearings.
2. Measure the distance X or Y between opposite surfaces of the bearing caps. Use a large micrometer of the correct size. **Figures 101 and 102.** Record the measurement.

Figure 101

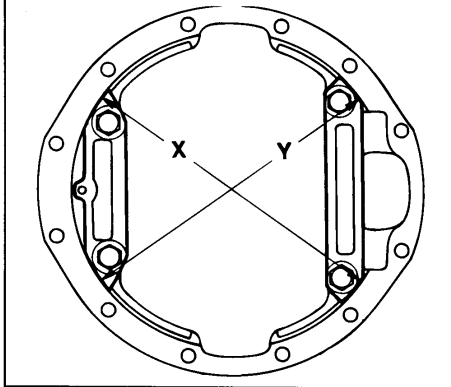
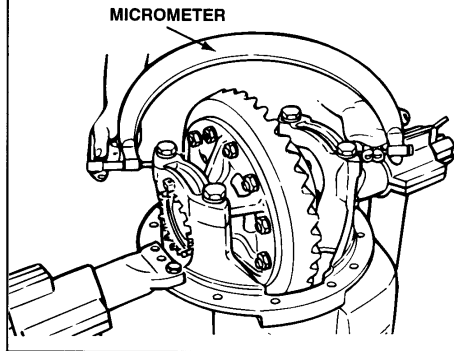


Figure 102



3. Tighten each bearing adjusting ring one notch.
4. Measure the distance X or Y again. Compare the dimension with the distance X or Y measured in step 2. The difference between the two dimensions is the amount the bearing caps have expanded.

Example

- Measurements of R-155 carrier
- Distance X or Y
 - before tightening adjusting rings = 13.927 inch (353.740 mm).
- Distance X or Y
 - after tightening adjusting rings = 13.936 inch (353.970 mm)
- $13.936 \text{ inch} - 13.927 \text{ inch} = 0.009 \text{ inch (0.230 mm)}$ difference.

If the dimension is within specifications, continue by checking runout of the ring gear. If the dimension is less than specifications, repeat steps 3 and 4 as needed.

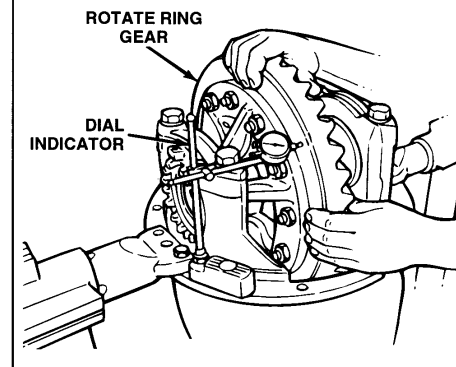
Inspect Runout of Ring Gear

Runout Specification

- 0.008 inch (0.200 mm)

1. Attach a dial indicator on the mounting flange of the carrier. **Figure 103.**

Figure 103



Section 5 Assembly

2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear.
3. Set the dial indicator to zero (0).
4. Rotate the differential and ring gear and read the dial indicator. The runout of the ring gear **must not exceed** 0.008 inch (0.200 mm). **Figure 103.**

If runout of the ring gear exceeds specifications, remove the differential and ring gear assembly from the carrier. Refer to the procedure on page 9 and the following steps 5 and 6.
5. Inspect the differential parts including the carrier for the problem that causes the runout of gear to exceed specifications. Repair or replace parts.
6. After the parts are repaired or replaced, install the differential and ring gear into the carrier. Refer to the procedure on page 44.
7. Repeat preload adjustment of differential bearings.

Ring Gear Backlash Adjustment

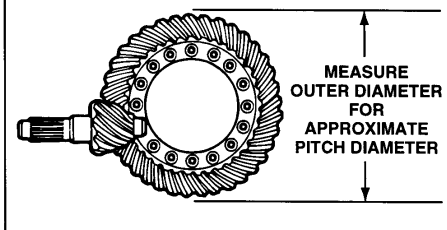
Specifications

- Ring gears that have a pitch diameter of less than 17 inches (431.8 mm)
 - Range of backlash setting: 0.008 to 0.018 inch (0.200-0.460 mm).
 - Backlash setting for new gear sets: 0.012 inch (0.300 mm)
- Ring gears that have a pitch diameter greater than 17 inches (431.8 mm)
 - Range of backlash setting: 0.010 to 0.020 inch (0.250-0.510 mm)
 - Backlash setting for new gear sets: 0.015 inch (0.380 mm)

NOTE:

Measure the outer diameter of ring gear for approximate pitch diameter. Figure 104.

Figure 104



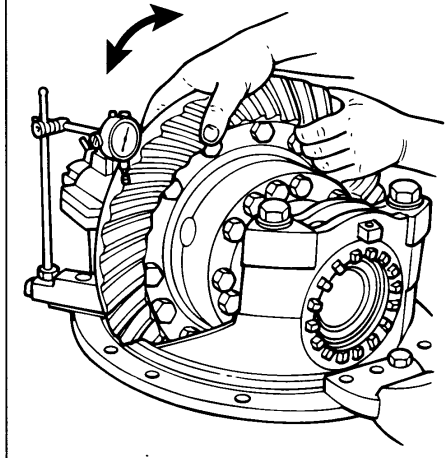
If the old gear set is installed, adjust the backlash to the setting that was measured before the carrier was disassembled.

If a new gear set is installed, adjust the backlash to the correct specification for new gear sets.

After inspection of the tooth contact patterns, the backlash can be adjusted within specification limits, if needed. To change the location of the pattern use the following procedures.

1. Attach a dial indicator on the mounting flange of the carrier. **Figure 105.**

Figure 105



Section 5 Assembly

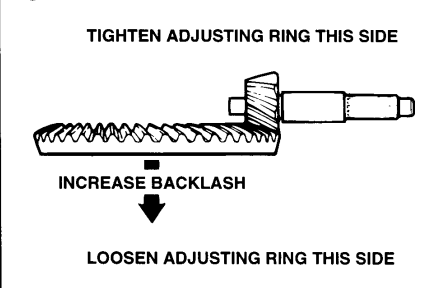
2. Adjust the dial indicator so that the plunger or pointer is against the tooth surface. **Figure 105.**
3. Adjust the indicator dial to zero (0).
4. Hold the drive pinion in position.
5. After reading the dial indicator, rotate the differential and ring gear a small amount in both directions, against the drive pinion teeth. If the backlash reading is within specification, continue inspecting tooth contact patterns. If the backlash reading is not within specifications, adjust backlash as needed. Continue following steps 6 and 7.

NOTE:

Backlash is increased by moving the ring gear away from the drive pinion. Figure 106.

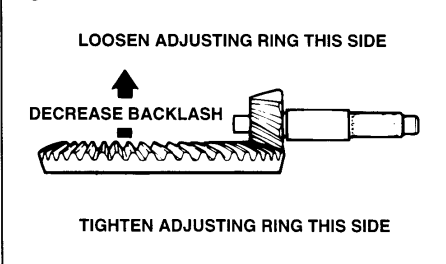
Backlash is decreased by moving the ring gear toward the drive pinion. Figure 107.

Figure 106



6. Loosen one bearing adjusting ring one notch then tighten the opposite ring the same amount. Refer to **Figures 106 and 107.**

Figure 107



NOTE:

When you adjust backlash, move the ring gear ONLY. DO NOT move the drive pinion.

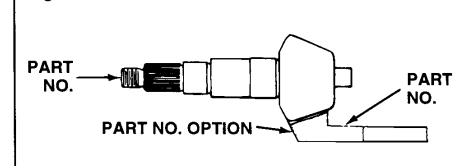
7. Repeat steps 2-6 until the backlash is within specifications.

Inspect Tooth Contact Patterns of the Gear Set

General Information

Rockwell carriers can have a conventional **HYPOID** gear set or a **GENEROID** hypoid gear set. The tooth contact patterns for each type of gear set are different. Look at the part numbers to see what type of gear set is in the carrier. Refer to **Figure 108** for the location of part numbers.

Figure 108



Examples of part numbers for conventional **HYPOID** gear sets.

- 36786 for the ring gear.
- 36787 for the drive pinion.

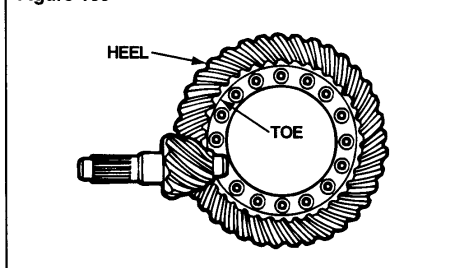
Examples of part numbers for **GENEROID** gear sets.

- 36786-K or 36786-K2 for the ring gear.
- 36787-K or 36787-K2 for the drive pinion.

Section 5 Assembly

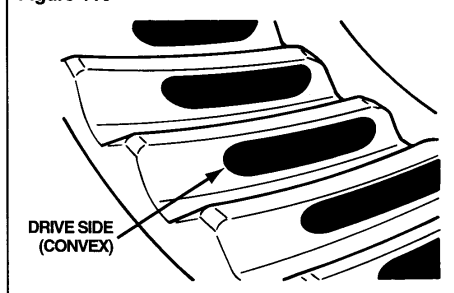
In the following procedures, movement of the contact pattern in the length of the tooth is indicated as, toward the "heel" or "toe" of the ring gear. **Figure 109.**

Figure 109



Always inspect tooth contact patterns on the drive side of the gear teeth. **Figure 110.**

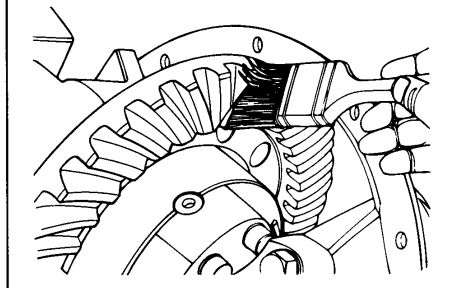
Figure 110



Tooth Contact Patterns of Conventional Hypoid and Generoid Hypoid Gear Sets

1. Adjust the backlash of a new gear set to either .012 inch (.300 mm) or .015 inch (.380 mm) depending on the size of the ring gear. Adjust the backlash of an old gear set to the setting that was measured before the carrier was disassembled. Refer to the procedure on page 48.
2. Apply a marking compound to approximately 12 gear teeth of the ring gear. Rotate the ring gear so that the 12 gear teeth are next to the drive pinion. **Figure 111.**

Figure 111



3. Rotate ring gear forward and backward so that the 12 gear teeth go past the drive pinion six times to get the contact patterns. Repeat if needed to get a more clear pattern.
4. Look at the contact patterns on the ring gear teeth. Compare the patterns to **Figures 112A or B, 113A or B, and 114A or B.**

The Location of Good Hand-Rolled Contact Patterns.

New Conventional and Generoid Gear Sets — toward the toe of the gear tooth and in the center between the top and bottom of the tooth. Refer to **Figures 112A and 112B.**

When the carrier is being operated, a good pattern will extend approximately the full length of the gear tooth. The top of the pattern will be near the top of the gear tooth. Refer to **Figure 115A or B.**

The location of a good hand-rolled contact pattern for an old gear set **must** match the wear pattern in the ring gear. The contact pattern will be smaller in area than the wear pattern.

If the contact patterns require adjustment, continue by following step 5 to move the contact patterns between the top and bottom of the gear teeth. If the contact patterns are in the center of the gear teeth, continue by following step 6.

5. Change the thickness of the shim pack under bearing cage to move the contact patterns between the top and bottom of the gear teeth. Use the following procedure.

Section 5 Assembly

Conventional Gears

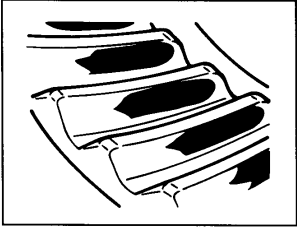


Figure 112A
Good Hand-Rolled Pattern

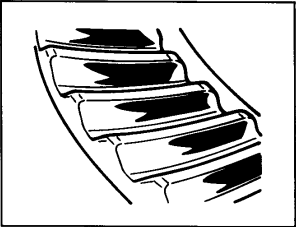


Figure 113A
High Pattern

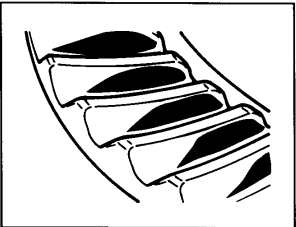


Figure 114A
Low Pattern

Generoid Gears

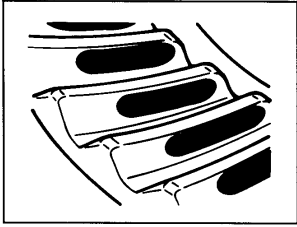


Figure 112B
Good Hand-Rolled Pattern

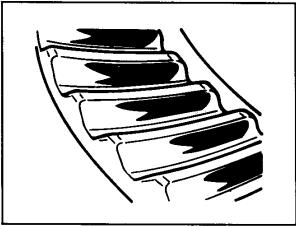


Figure 113B
High Pattern

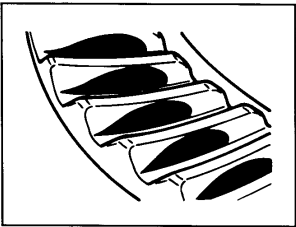
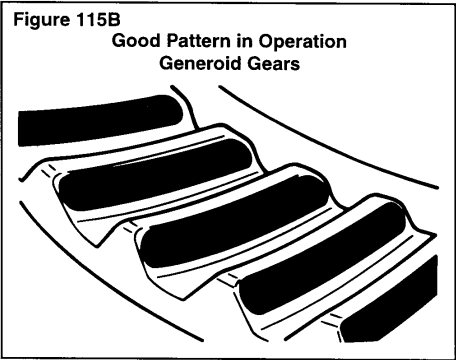
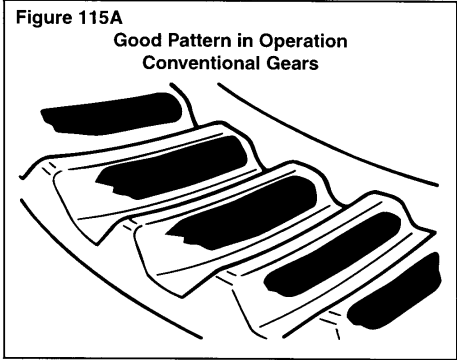


Figure 114B
Low Pattern



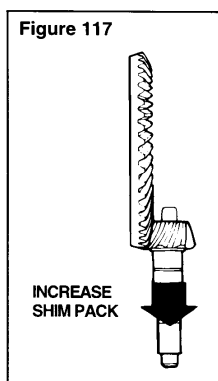
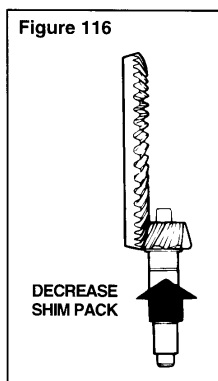
Section 5 Assembly

NOTE:

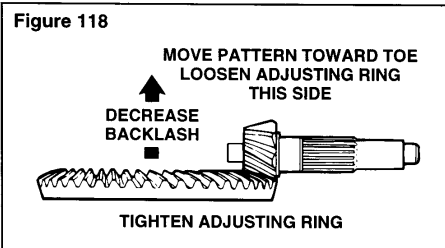
A high contact pattern indicates that the drive pinion was not installed deep enough into the carrier. A low contact pattern indicates that the drive pinion was installed too deep in the carrier.

- Remove the drive pinion and bearing cage from the carrier. Refer to the procedure on page 12.
- To correct a high contact pattern, **Figure 113A** decrease the thickness of the shim pack under the bearing cage. When decreasing the thickness of the shim pack, the drive pinion will move toward the ring gear. **Figure 116.**

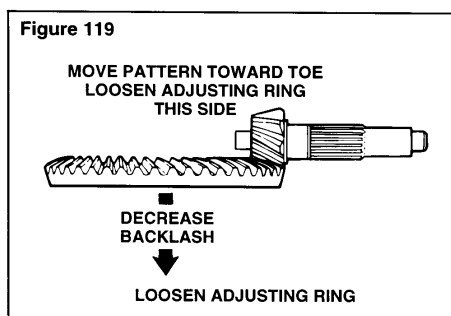
To correct a low contact pattern, **Figure 117** increase the thickness of shim pack under the bearing cage. When increasing the thickness of the shim pack, the drive pinion will move away from the ring gear. **Figure 117.**



- Install the drive pinion, bearing cage and shims into the carrier. Refer to the procedure on page 36.
- Repeat steps 2-5 until the contact patterns are in the center between the top and bottom of the gear teeth.
- Adjust backlash of the ring gear within specification range to move the contact patterns to the correct location in the length of the gear teeth. Refer to the procedure on page 48.
 - Decrease backlash to move the contact patterns toward the toe of the ring gear teeth. **Figure 118.**



- Increase backlash to move the contact patterns toward the heel of the ring gear teeth. **Figure 119.**



- Repeat steps 2-4 and 6 until the contact patterns are at the correct location in the length of the gear teeth.
- Install cotter keys*, pins*, or lock plates* that hold the two bearing adjusting rings in position. Use the following procedures.

CAUTION

If the carrier has cotter keys, lock the adjusting rings only with cotter keys. If your carrier has roll pins, reuse the roll pins or lock the adjusting rings with cotter keys. Do not force a roll pin into a cotter key hole.

Section 5 Assembly

a. **Cotter Keys** — Install cotter keys between lugs of the adjusting ring and through the boss of the bearing cap. Bend the two ends of the cotter key around the boss. **Figure 120.**

b. **Pins** — Install pin through boss of the bearing cap until the pin is between lugs of the adjusting ring. Use a drift and hammer to install the pin. **Figure 120.**


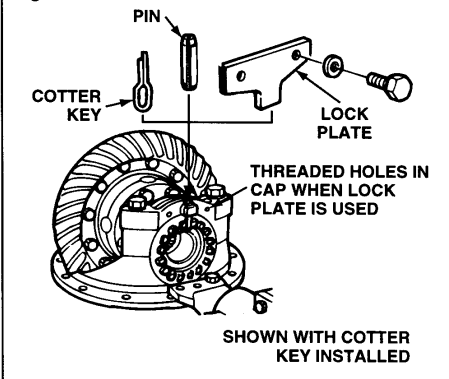
c. **Lock Plates** — Install lock plate on bearing cap so that the tab is between lugs of the adjusting ring. Install the two capscrews that hold the lock plate to the bearing cap. Tighten the capscrews to correct torque value. Refer to the Torque Chart on page 61. **Figure 120.** 

Figure 120



Install and Adjust the Thrust Screw*

Specification

- Clearance between thrust screw and ring gear — 0.025 to 0.045 inch (0.650-1.140 mm).
- Loosen the thrust screw 1/2 turn or 180°.

If the carrier does not have a thrust block*, start at step 4.

1. Rotate the carrier in the repair stand until the back surface of ring gear is toward the top. **Figure 121.**
2. Place the thrust block on the back surface of the ring gear. The thrust block **must** be in the center between the outer diameter of gear and differential case.

3. Rotate the ring gear until the thrust block and hole for thrust screw, in carrier, are aligned. **Figure 121.**

4. Install the jam nut on the thrust screw, one half the distance between both ends.

5. Install the thrust screw into the carrier until the screw stops against the ring gear or thrust block. **Figure 122.**

Figure 121

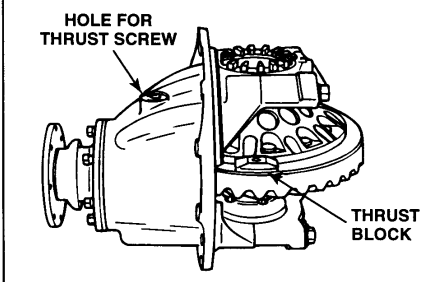
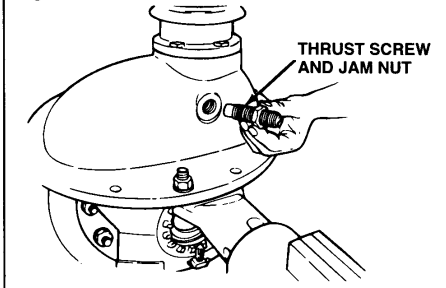
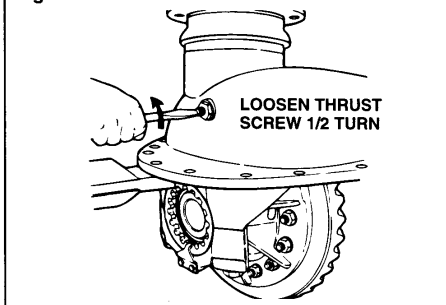


Figure 122



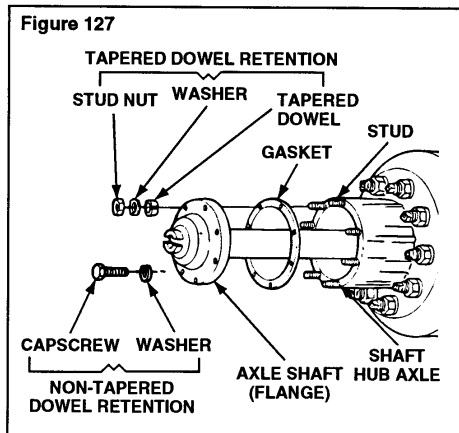
6. Loosen the thrust screw* 1/2 turn, 180°. **Figure 123.**

Figure 123



Section 5 Assembly

8. Carefully push the carrier into position. Tighten the four fasteners two or three turns each in a pattern opposite each other. Refer to **Figure 126**.
9. Repeat step 8 until the four fasteners are tightened to the correct torque value. Refer to the Torque Chart on page 61. **1**
10. Install the other fasteners and washers that hold the carrier in the axle housing. Tighten fasteners to the correct torque value. Refer to the Torque Chart on page 61. **1**
11. Connect the driveline universal joint to the pinion input yoke or flange on the carrier.
12. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts **must** fit flat against the wheel hub. **Figure 127**.



Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 1/8-inch diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole in that surface.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft **MUST** fit flat against the wheel hub. Refer to **Figure 127**.
4. Install the Grade 8 nuts and hardened washers on the stud. (Lock washers are an acceptable alternative.) Tighten the stud nuts to the torque specified in **Chart 3**.

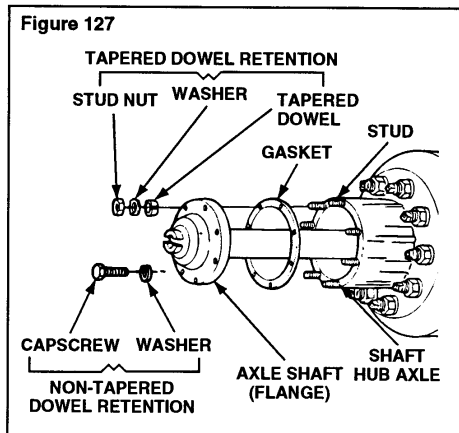
Chart 3

Shaft-to-Hub Torque Fastener Chart—Non-tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) 1	
		Plain Nut	Lock Nut
Stud Nut (Axle Shaft)	.62-18	150-230 (203-312)	130-190 (176-258)
	.75-16	310-400 (420-542)	270-350 (366-475)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Section 5 Assembly

8. Carefully push the carrier into position. Tighten the four fasteners two or three turns each in a pattern opposite each other. Refer to **Figure 126**.
9. Repeat step 8 until the four fasteners are tightened to the correct torque value. Refer to the Torque Chart on page 61. **1**
10. Install the other fasteners and washers that hold the carrier in the axle housing. Tighten fasteners to the correct torque value. Refer to the Torque Chart on page 61. **1**
11. Connect the driveline universal joint to the pinion input yoke or flange on the carrier.
12. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts **must** fit flat against the wheel hub. **Figure 127**.



Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 1/8-inch diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole in that surface.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft **MUST** fit flat against the wheel hub. Refer to **Figure 127**.
4. Install the Grade 8 nuts and hardened washers on the stud. (Lock washers are an acceptable alternative.) Tighten the stud nuts to the torque specified in **Chart 3**.

Chart 3

Shaft-to-Hub Torque Fastener Chart—Non-tapered Dowel Applications


Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) 1	
		Plain Nut	Lock Nut
Stud Nut (Axle Shaft)	.62-18 .75-16	150-230 (203-312) 310-400 (420-542)	130-190 (176-258) 270-350 (366-475)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Section 5 Assembly

Tapered Dowel, Hardened Washer and Hardened Nut

- Clean the mating surfaces of the axle shaft and the wheel hub.
 - If silicone gasket material is used, apply a 1/8-inch diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole in that surface.
 - Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft **MUST** fit flat against the wheel hub. Refer to **Figure 127**.
- Install solid tapered dowels over each stud and into the flange of the axle shaft. Use a punch or a drift and hammer, if necessary.
 - Install the Grade 8 nuts and hardened washers on the stud. (Lock washers are an acceptable alternative.) Tighten the stud nuts to the torque specified in **Chart 4**.

Chart 4
Shaft-to-Hub Torque Fastener Chart — Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) 	
		Plain Nut	Lock Nut
Stud Nut (Axle Shaft)	.44-20	50–75 (81–102)	40–65 (67–88)
	.50-20	75–115 (115–156)	65–100 (102–136)
	.56-18	110–165 (176-224)	100–145 (149–197)
	.62-18	150–230 (203–312)	130–190 (176–258)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Section 6 Lubrication

NOTE:

For complete information on lubricating drive axles and carriers, refer to Rockwell Maintenance Manual No. 1.

Refer to the following **Charts 5, 6 and 7** for standard information on lubricants, schedules and capacities.

Chart 5

Lubricant Cross Reference (Viscosity) and Temperature Chart

Rockwell Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
O-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	+10°F (−12.2°C)	... **
O-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	−15°F (−26.1°C)	... **
O-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	−15°F (−26.1°C)	... **
O-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	−40°F (−40°C)	... **
O-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	−40°F (−40°C)	+35°F (+1.6°C)
O-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	−40°F (−40°C)	... **
** There is no upper limit on these outside temperatures, but the axle sump temperature <i>must never exceed</i> 250°F (+121°C).				

Chart 6

Rear Drive Axle Oil Change Intervals and Specifications^①

APPLIES TO ALL REAR AXLES EXCEPT THE "ADVANCED LUBE" REAR AXLES.

On-Highway Operation Intervals				Off-Highway Operation Intervals ②				Rockwell Specifications (Military)	Oil Description	Outside Temperature			
Initial Oil Change	Inspect Oil Level	Petroleum Oil Change	Synthetic Oil Change	Initial Oil Change	Inspect Oil Level	Petroleum Oil Change ③	Synthetic Oil Change			F°		C°	
										Min.	Max.	Min.	Max.
3,000 miles (4,800 km)	3,000 miles (4,800 km), once a month or the fleet maintenance interval (whichever comes first)	If annual mileage is less than 100,000 miles (160,000 km) change oil once a year.	250,000 miles (400,000 km)	1,000 miles (1,600 km)	1,000 miles (4,800 km)	If annual mileage is less than 60,000 miles (96,000 km) change oil twice a year.	50,000 miles (80,000 km)	O-76A, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 85W/140	10	None	−12	None
								O-76D, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 80W/90	−15	None	−26	None
								O-76E, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 75W/90	−40	None	−40	None
								O-76J, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 75W	−40	35	−40	2
								O-76L, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 75W/140	−40	None	−40	None
								O-76M, Full Synthetic Gear Oil (MIL-L-2105D or MIL-PRF-2105E)	GL-5, SAE 75W/140	−40	None	−40	None
		O-76N, Full Synthetic Gear Oil (MIL-L-2105D or MIL-PRF-2105E)						GL-5, SAE 75W/90	−40	None	−40	None	
3,000 miles (4,800 km)	3,000 miles (4,800 km), once a month or the fleet maintenance interval (whichever comes first)	If annual mileage is more than 100,000 miles (160,000 km), change oil every 100,000 miles (160,000 km).	250,000 miles (400,000 km)	1,000 miles (1,600 km)	1,000 miles (4,800 km)	If annual mileage is more than 60,000 miles (96,000 km), change oil every 30,000 miles (48,000 km).	50,000 miles (80,000 km)						

NOTES:

- ① If oil pump and filter is used, change filter every 100,000 miles (160,000 km). Inspect oil level. Add correct oil as required.
- ② Includes heavy-duty on-highway and on/off-highway applications.
- ③ For continuous heavy-duty operation, inspect oil level every 1,000 miles (1,600 kilometers).

Section 6 Lubrication

“Advanced Lube” Rear Drive Axle without Oil Pump and Filter Oil Change Intervals and Specifications^①

APPLIES TO TANDEM REAR AXLES MANUFACTURED AFTER JANUARY 1, 1993 EQUIPPED WITH
“MEMBRANE” TYPE BREATHERS AND ADVANCED MATERIAL TRIPLE-LIP SEALS.

On-Highway Operation Intervals			On-/Off-Highway Operation Intervals ②			Rockwell Specifications (Military)	Oil Description	Outside Temperature			
Inspect Oil Level	Petroleum Oil Change ③	Synthetic Oil Change ④	Inspect Oil Level ⑤	Petroleum Oil Change ③	Synthetic Oil Change ④			F°		C°	
								Min.	Max.	Min.	Max.
3,000 miles (4,800 km), once a month or the fleet maintenance interval (whichever comes first)	100,000 miles (160,000 km)	250,000 miles (400,000 km)	3,000 miles (4,800 km) or 200 hours of operation	40,000 miles (64,000 km)	80,000 miles (128,000 km)	O-76A, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 85W/140	10	None	-12	None
						O-76D, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 80W/90	-15	None	-26	None
						O-76E, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	-40	None	-40	None
						O-76J, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W	-40	35	-40	2
						O-76L, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	-40	None	-40	None
						O-76M, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	-40	None	-40	None
						O-76N, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	-40	None	-40	None

NOTES:

- ① If a No-Spin differential is installed, oil (petroleum or synthetic) must be changed at minimum interval of 64,000 km (40,000 miles) or a maximum interval of 50,000 miles (80,000 km).
- ② Also applies to heavy-duty on-highway applications. Does not apply to off-highway applications.
- ③ For petroleum oil with extended drain additives, use the “Synthetic Oil Change” interval.
- ④ Applies to semi-synthetic oils and full-synthetic oils. For a list of approved synthetic oils, refer to Rockwell Maintenance Manual No. 1.
- ⑤ For continuous heavy-duty operation, inspect the oil level every 1,000 miles (1,600 km). Add the correct oil as required.

Tandem “Advanced Lube” Rear Drive Axle with Oil Pump and Filter Oil Change Intervals and Specifications^{②③}

APPLIES TO TANDEM REAR AXLES MANUFACTURED AFTER JANUARY 1, 1993 EQUIPPED WITH
“MEMBRANE” TYPE BREATHERS AND ADVANCED MATERIAL TRIPLE-LIP SEALS.

On-Highway Operation Intervals			On-/Off-Highway Operation Intervals ③			Rockwell Specifications (Military)	Oil Description	Outside Temperature			
Inspect Oil Level	Petroleum Oil Change ④	Synthetic Oil Change ⑤	Inspect Oil Level ⑥	Petroleum Oil Change ④	Synthetic Oil Change ⑤			F°		C°	
								Min.	Max.	Min.	Max.
3,000 miles (4,800 km) once a month or the fleet maintenance interval (whichever comes first)	100,000 miles (160,000 km)	500,000 miles (800,000 km)	3,000 miles (4,800 km) or 200 hours of operation	50,000 miles (80,000 km)	100,000 miles (160,000 km)	O-76A, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 85W/140	10	None	-12	None
						O-76D, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 80W/90	-15	None	-26	None
						O-76E, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	-40	None	-40	None
						O-76J, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W	-40	35	-40	2
						O-76L, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	-40	None	-40	None
						O-76M, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	-40	None	-40	None
						O-76N, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	-40	None	-40	None

NOTES:

- ① Replace oil filter every 100,000 miles (160,000 km). Inspect oil level. Add specified oil as required.
- ② If No-Spin differential is installed, oil (petroleum or synthetic) must be changed at minimum interval of 40,000 miles (64,000 km) or a maximum interval of 50,000 miles (80,000 km).
- ③ Applies to heavy-duty on-highway applications and to on/off highway applications. Does not apply to off-highway applications.
- ④ For petroleum oil with extended drain additives, use the “Synthetic Oil Change” interval.
- ⑤ Applies to semi-synthetic oils. For list of approved synthetic oils, refer to Rockwell Maintenance Manual No. 1.
- ⑥ For continuous heavy-duty operation, inspect oil level every 1,000 miles (1,600 km). Add correct oil as required.

Section 6 Lubrication

Chart 7

Lubricant Capacities

Use the following lubricant capacities as a guide only. The capacities are measured with the drive pinion in the horizontal position. When the angle of the drive pinion changes, the lubricant capacity of the axle will change.

Axle Model	Capacity	
	U.S. Pints	Liters
Single Drive Axles		
A-150	5.5	2.6
B-100	10	4.7
B-140	12	5.7
B-150	3.5	1.7
C-100	12.5	5.9
D-100	12.5	5.9
D-140	12.5	5.9
E-100	15	7.1
E-105	12.5	5.9
E-150	9	4.3
F-100	13	6.2
F-106	13	6.2
F-120	15	7.1
F-121	15	7.1
F-140	14	6.6
FDS-75	14	6.6
FDS-78	14	6.6
FDS-85	15	7.1
FDS-90	14	6.6
FDS-93	14	6.6
FDS-750	7	3.3
FDS-1600	23	10.9
FDS-1800	35	16.6
FDS-1805	35	16.6
FDS-1807	27	13.2
FDS-1808	27.9	13.2
FDS-2100	27.9	13.2
FDS-2101	27.9	13.2
FDS-2107	43	20.3
FDS-2110	43	20.3
FDS-2111	43	20.3
FDS-2117	43	20.3
G-161	21	9.9
H-100	20	9.5
H-140	21	9.9
H-150	11	5.2
H-162	20	9.5
H-170	27*	12.8
H-172	27	12.8
L-100	23	10.9
L-140	24	11.4

Axle Model	Capacity	
	U.S. Pints	Liters
Single Drive Axles (Continued)		
L-155	24	11.4
L-172	27	12.8
M-172	27	12.8
QT-140	24	11.4
Q-100	31	14.7
Q-145	24	11.4
RL-170	48	22.7
R-100	30	14.2
R-140	28	13.2
R-155	28	13.2
R-160	28	13.2
R-163	34	16.1
R-170	43	20.3
S-170	43	20.3
U-140	24	11.4
U-170	43	20.3
W-170	43	20.3

* Includes 1 pint (0.97 liter) for each wheel end and with drive pinion angle at 3°.

Axle Model	Capacity	
	U.S. Pints	Liters
Rear Axle of Tandems		
SDHD (DHR rear)	16	7.6
SFHD (FHR rear)	16.5	7.8
SHHD (HHR rear)	26	12.3
SL-100 (LR-100 rear)	37	17.5
SLHD (LHR rear)	32	15.1
SQ-100 (QR-100 rear)	33	15.7
SQHD (QHR rear)	31	14.7
SQHP (QAR rear)	36	17
SR-170 (RR-170 rear)	43	20.3
SRHD (RHR rear)	36	17
SSHD (SHR rear)	28	13.2
ST-170 (TR-170 rear)	43	20.3
STHD (THR rear)	28	13.2
SU-170 (UR-170 rear)	43	20.3
SUHD (UHR rear)	28	13.2
SW-170 (WR-170 rear)	43	20.3

Section 7

Fastener Torque Information

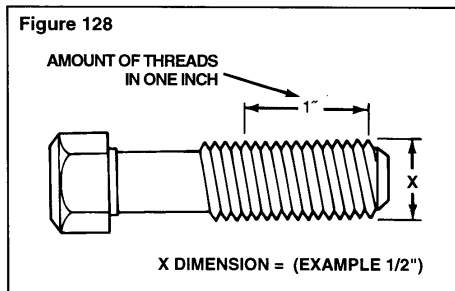
Torque Values for Fasteners

General Information

1. The torque values in **Chart 8** are for fasteners that have a light application of oil on the threads.
2. If the fasteners are dry, increase the torque values by ten percent (10%).
3. If the fasteners have a heavy application of oil on the threads, decrease the torque values by ten percent (10%).
4. If you do not know the size of the fastener that is being installed, measure the fastener. Use the following procedure.

American Standard Fasteners

- a. Measure the diameter of the threads in inches, dimension X. **Figure 128.**



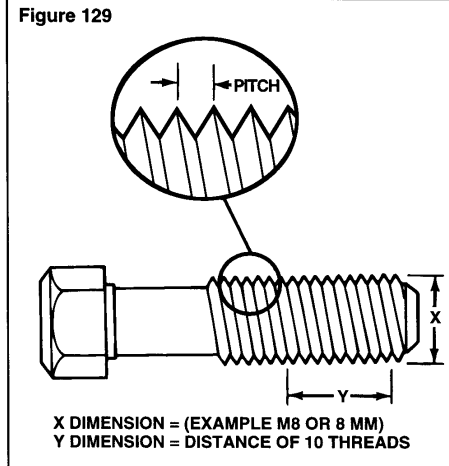
- b. Count the amount of threads there are in one inch (1.0 inch). **Figure 128.**

Example

- American Standard size fastener is .50-13.
 - 0.50 is the diameter of the fastener in inches or dimension X.
 - 13 is the amount of threads in one inch (1.0 inch).

Metric Fasteners

- a. Measure the diameter of the threads in millimeters (mm), dimension X. **Figure 129.**



- b. Measure the distance of ten (10) threads, point to point in millimeters (mm), dimension Y. Make a note of dimension Y. **Figure 129.**
- c. Divide dimension Y by ten (10). The result will be the distance between two threads or pitch.

Example

- Metric size fastener is M8 x 1.25.
 - M8 is the diameter of the fastener in millimeters (mm) or dimension X.
 - 1.25 is the distance between two threads or pitch.
- 5. Compare the size of fastener measured in step 4 to the list of fasteners in **Chart 8** to find the correct torque value.

Section 7

Fastener Torque Information

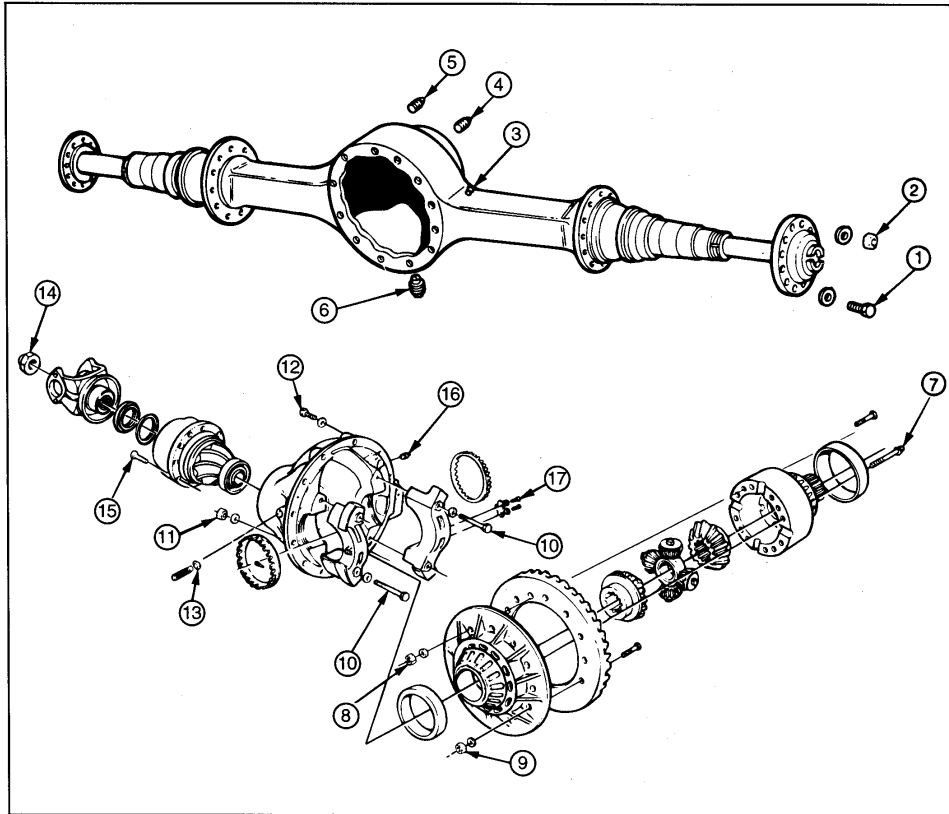



Chart 8

Torque Chart


Fastener		Thread Size	Torque Value lb-ft (N•m) 	
1.	*Capscrew, Axle Shaft	.31-24	18-24	(24-33)
		.50-13	85-115	(115-156)
2.	*Nut, Axle Shaft Stud	Plain Nut		
		.44-20	50-75	(68-102)
		.50-20	75-115	(102-156)
		.56-18	110-165	(149-224)
		.62-18	150-230	(203-312)
		Lock Nut		
		.44-20	40-65	(54-88)
		.50-20	65-100	(88-136)
		.56-18	100-145	(136-197)
		.62-18	130-190	(176-258)

*Some Rockwell carriers do not have these described parts.

Section 7

Fastener Torque Information


Chart 8 (Continued)

	Fastener	Thread Size	Torque Value lb-ft (N•m) 	
3.	Breather	.38-18	20 minimum (27 minimum)	
4.	*Plug, Oil Fill (Housing)	.75-14	35 minimum (47.5 minimum)	
5.	*Plug, Heat Indicator	.50-14	25 minimum (34 minimum)	
6.	Plug, Oil Drain	.50-14	25 minimum (34 minimum)	
7.	Capscrew, Differential Case	.38-16 .44-14 .50-13 .56-12 .62-11 Grade 10.9 Flange Head M12 x 1.75 Grade 10.9 Standard Hex Head M12 x 1.75 Grade 12.9 Standard Hex Head M12 x 1.75 Grade 12.9 Flange Head M16 x 2 Grade 12.9 Standard Head M16 x 2	35-50 60-75 85-115 130-165 180-230 85-103 74-96 105-125 203-251 220-310	(48-68) (81-102) (115-156) (176-224) (244-312) (115-140) (100-130) (143-169) (275-340) (300-420)
8.	*Nut, Differential Case Bolt	.50-13 .50-20 .62-11 .62-18 M12 x 1.75 M16 x 2	75-100 85-115 150-190 180-230 74-96 220-310	(102-136) (115-156) (203-258) (244-312) (100-130) (300-420)
9.	*Nut, Ring Gear Bolt	.50-13 .50-20 .62-11 .62-18 M12 x 1.25 M12 x 1.75 Flange Head M16 x 1.5 Standard Hex Head M16 x 1.5	75-100 85-115 150-190 180-230 66-81 77-85 192-214 196-262	(102-136) (115-156) (203-258) (244-312) (90-110) (104-115) (260-190) (265-355)
10.	Capscrew, Bearing Cap	.56-12 .62-11 .75-10 .88-14 .88-9 M16 x 2 M20 x 2.5 M22 x 2.5	110-145 150-190 270-350 360-470 425-550 181-221 347-431 479-597	(149-197) (203-258) (366-475) (488-637) (576-746) (245-300) (470-585) (650-810)
11.	Nut, Housing to Carrier Stud	.44-20 .50-20 .56-18 .62-18	50-75 75-115 110-165 150-230	(68-102) (102-156) (149-224) (203-312)
12.	Capscrew, Carrier to Housing	.44-14 .50-13 .56-12 .62-11 .75-10 M12 x 1.75 M16 x 2	50-75 75-115 110-165 150-230 270-400 74-89 181-221	(68-102) (102-156) (149-224) (203-312) (366-542) (100-120) (245-300)

Section 7

Fastener Torque Information

Chart 8 (Continued)

Fastener		Thread Size	Torque Value lb-ft (N•m) 	
13.	*Jam Nut, Thrust Screw	.75-16	150-190	(203-258)
		.88-14	150-300	(203-407)
		1.12-16	150-190	(203-258)
		M22 x 1.5	148-210	(200-285)
		M30 x 1.5	236-295	(320-400)
14.	Nut, Drive Pinion	.88-20	200-275	(271-373)
		1.0-20	300-400	(407-542)
		1.25-12	700-900	(949-1220)
		1.25-18	700-900	(949-1220)
		1.50-12	800-1100	(1085-1491)
		1.50-18	800-1100	(1085-1491)
		1.75-12	900-1200	(1220-1627)
		M32 x 1.5	738-918	(1000-1245)
		M39 x 1.5	922-1132	(1250-1535)
		M45 x 1.5	996-1232	(1350-1670)
15.	Capscrew, Bearing Cage	.38-16	30-50	(41-68)
		.44-14	50-75	(68-102)
		.50-13	75-115	(102-156)
		.56-12	110-165	(149-224)
		.62-11	150-230	(203-312)
		M12 x 1.75	70-110	(90-150)
16.	*Plug, Oil Fill (Carrier)	.75-14	25 minimum (34 minimum)	
		1.5-11.5	120 minimum (163 minimum)	
		M24 x 1.5	35 minimum (47 minimum)	
17.	*Capscrew, Lock Plate	.31-18	20-30	(27-41)
		M8 x 1.25	21-26	(28-35)



*Some Rockwell carriers do not have these described parts.

Section 8

Adjustments and Specifications

Drive Pinion Bearings — Preload

Page

Specification	New bearings — 5 to 45 lb-in (0.56-5.08 N•m) torque  Used bearings — 10 to 30 lb-in (1.13-3.39 N•m) torque 	32
Adjustment	Preload is controlled by the thickness of the spacer between bearings. — To increase preload install a thinner spacer — To decrease preload install a thicker spacer	


Drive Pinion — Depth in Carrier

Specification	Install the correct amount of shims between the bearing cage and carrier. To calculate, use old shim pack thickness and new and old pinion cone numbers.	36-38
Adjustment	Change the thickness of the shim pack to get a good gear tooth contact pattern.	

Hypoid Gear Set — Tooth Contact Patterns (Hand Rolled)

Specification	Conventional gear set — Toward the toe of the gear tooth and in the center between the top and bottom of the tooth Generoid gear set — Between the center and toe of the tooth and in the center between the top and bottom of the tooth	49
Adjustment	Tooth contact patterns are controlled by the thickness of the shim pack between the pinion bearing cage and carrier and by ring gear backlash — To move the contact pattern lower, decrease the thickness of the shim pack under the pinion bearing cage — To move the contact pattern higher, increase the thickness of the shim pack under the pinion bearing cage — To move the contact pattern toward the toe of the tooth, decrease backlash of the ring gear — To move the contact pattern toward the heel of the tooth, increase backlash of the ring gear	

Main Differential Bearings — Preload


Specification	15 to 35 lb-in (1.7-3.9 N•m) torque  or Expansion between bearing caps — R-140, R-155 and R-160 carrier models — 0.002 to 0.009 inch (0.050-0.229 mm) — All other carrier models — 0.006 to 0.013 inch (0.150-0.330 mm)	45
Adjustment	Preload is controlled by tightening both adjusting rings after zero end play is reached	

Section 8

Adjustments and Specifications

Main Differential Gears — Rotating Resistance

Page

Specification	50 lb-ft (68 N•m) torque applied to one side gear 	43
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Ring Gear — Backlash

Specification	Ring gears that have a pitch diameter of less than 17 inches (431.8 mm) <ul style="list-style-type: none"> — Range: 0.008 to 0.018 inch (0.200-0.460 mm) 0.012 inch (0.300 mm) for a new gear set Ring gears that have a pitch diameter of 17 inches (431.8 mm) or greater <ul style="list-style-type: none"> — Range: 0.010 to 0.020 inch (0.250-0.510 mm) 0.015 inch (0.380 mm) for a new gear set 	48
Adjustment	Backlash is controlled by the position of the ring gear. Change backlash within specifications to get a good tooth contact pattern. <ul style="list-style-type: none"> — To increase backlash, move the ring gear away from the drive pinion — To decrease backlash, move the ring gear toward the drive pinion 	

Ring Gear — Runout

Specification	0.008 inch (0.200 mm) maximum	47
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Spigot Bearing — Peening on the Drive Pinion

Specification	Apply 6,614 lb (3,000 kg) load on a 0.375 inch or 10 mm ball. Peen the end of the drive pinion at a minimum of five points. Softening of the pinion stem end by heating may be required.	28-29 29
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Section 9

Vehicle Towing Instructions (Non DCDL)

SINGLE AXLE without Driver Controlled Main Differential Lock (DCDL)

TANDEM AXLE without Driver Controlled Main Differential Lock (DCDL), with Inter-Axle Differential (IAD)

These instructions are for vehicles equipped with Rockwell single or tandem rear drive axles.

The instructions supersede all other instructions for the purpose of transporting vehicles for service or new vehicle drive-away dated before April 1995, including those contained in Rockwell Maintenance Manuals.

When transporting a vehicle with the wheels of one or both drive axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins. Rockwell recommends that you use the following procedure.

Before Towing or Drive-Away



WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.



WARNING

Do not work under a vehicle unless the parking brake is engaged. The vehicle can move and cause serious personal injury if the parking brake is not applied before maintenance tasks are begun.

1. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.

NOTE:

Single Axle continue with step 5. Tandem Axle continue with step 2.

2. Shift the transmission into neutral and start the vehicle's engine.
3. Shift the IAD to the unlocked (disengaged) position using the switch inside the cab of the vehicle. The indicator light in the cab will go off.
4. Stop the engine.

NOTE:

Remove both axle shafts from the axle(s) that will remain on the road when the vehicle is transported. Continue with step 5 for both axle shafts.

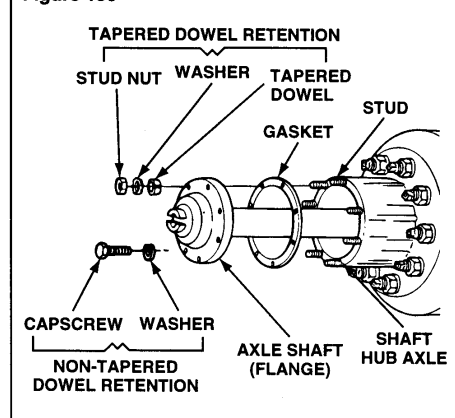
5. Remove the stud nuts or capscrews and the washers from the flange of the axle shaft. **Figure 130.**
6. Loosen the tapered dowels, if used, in the flange of the axle shaft using one of the two following methods. **Figure 130.**



CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

Figure 130



Section 9

Vehicle Towing Instructions (Non DCDL)

Brass Drift Method:

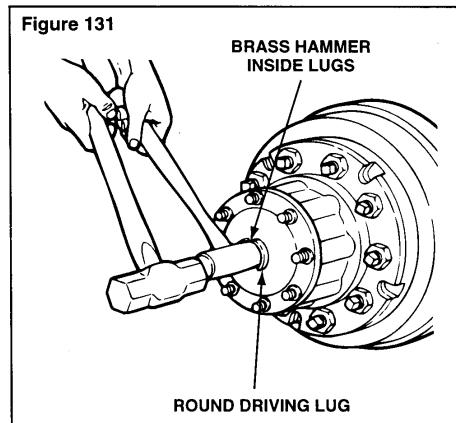
WARNING

Wear safe eye protection. Do not directly strike or hit the round driving lugs on the flange of the axle shaft. Striking the lugs can cause them to break off from the axle shaft hub resulting in serious personal injury.

NOTE:

A 1.5 inch (38.1 mm) diameter brass hammer can be used as a drift.

- Hold a 1.5 inch (38.1 mm) diameter brass drift against the center of the axle shaft flange, inside the round driving lugs. **Figure 131.**



- Hit the end of the drift with a large hammer (5 to 6 lbs, 2 to 3 kg) to loosen the axle shaft and tapered dowels from the hub. **Figure 131.**

Air Hammer Vibration Method:

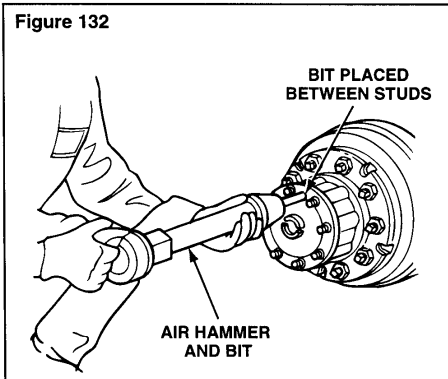
WARNING

Wear safe eye protection when using an air hammer. Power tools and components can loosen and break and cause serious personal injury.

- Use an air hammer, such as Chicago Pneumatic CP-4181-PULER, or equivalent, with a round hammer bit to loosen the axle shaft and dowels.

- Place the round hammer bit against the axle shaft flange between the studs, at different points around the flange. Operate the air hammer at each location and loosen the axle shaft and tapered dowels from the hub. **Figure 132.**

Figure 132



- Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed. (Example: Match mark a mating axle shaft and hub.)
- Remove the tapered dowels, gasket (if used) and the axle shaft from the axle assembly. **Figure 130**, page 66.
- Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE:

If an air supply will be used for the brake system of the transported vehicle, continue with steps 10 and 11, otherwise continue with step 12.

- Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with step 12.
- When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 12 is not required.

Section 9

Vehicle Towing Instructions (Non DCDL)

WARNING

When you work on a spring (parking) brake, carefully follow the service instructions of the chamber manufacturer to manually compress the spring. Sudden release of a compressed spring can cause serious personal injury.

- If there are spring (parking) brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

WARNING

To prevent serious eye injury, always wear safe eye protection when performing vehicle maintenance or service.

WARNING

Do not work under a vehicle unless the parking brake is engaged. The vehicle can move and cause serious personal injury if the parking brake is not applied before maintenance tasks are begun.

- If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with step 2.

WARNING

When you work on a spring (parking) brake, carefully follow the service instructions of the chamber manufacturer to manually release the spring. Sudden release of a compressed spring can cause serious personal injury.

- Apply the vehicle spring (parking) brakes by manually releasing each spring that was compressed before transporting started. Refer to manufacturer's instructions.
- Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.


- Remove the covers from the hubs.

NOTE:

Continue with steps 5 through 7 to install all axle shafts.

- Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location it was removed from. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft and/or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. **Figure 130**, page 66.
- Install the dowels, if used, over each stud and into the tapered holes of the flange.
- Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the corresponding torque value shown in **Chart 9** below.

Chart 9

	Thread Size	Torque Value lb-ft (N•m) 
Capscrews:	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts: (plain nuts)	0.44"-20	50-75 (68-102)
	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
(lock nut)	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

- Inspect the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. For information about lubrication, refer to the Rockwell Maintenance Manual, MM No. 1, Lubrication, or refer to the Lubrication Section of the Rockwell Maintenance Manual for the axle model you are working with.

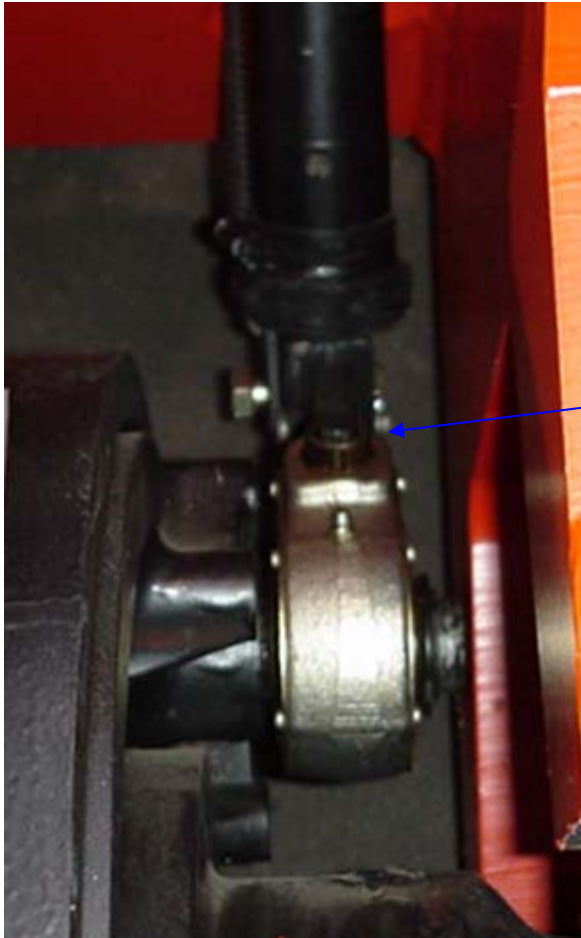
F-Series Brakes

Procedure to make adjustments to the slack adjusters

To make the adjustments to the slack adjusters do the following:

- Using a 9/16 socket push in on the adjuster screw.
- Turn in the screw counter-clockwise till the brakes are tight to the drum.
- Back off the screw about $\frac{3}{4}$ to $\frac{1}{2}$ turn

Note: The brake cylinder must only stroke 1" to 1 1/4"



Adjusting Screw

burnish-procedure.doc

Subject: drum brake burnish procedure

Here is a typical drum brake burnish procedure that has been used to increase the effectiveness of new linings and/or help renew used surfaces.

DRAG BURNISH PROCEDURE:

1. Drag brakes until the hottest drum is up to about 300 degrees F. Then cool back to about 150-200 degrees F or less.

Repeat 3 times.

2. Drag brakes until the hottest drum is up to about 450 degrees F. Then cool back to about 250-300 degrees F or less.

Repeat 3 times.

3. Cool to ambient temperature and check for adequate braking performance.

4. If necessary, repeat 1, 2, and 3 until performance is satisfactory (or until there is no further improvement).

NOTE:

- a) Temperature references are at the drum inside diameter (rubbing surface). If taken at the drum end surface or outside surface of the drum, reduce the above maximum temperature limitations by 50 degrees [In order to get a "good" measurement, make sure the area on the surface measured is clean and free of dirt/debris; and get the measurement right away after the drag ceases.]

- b) Definition: "Drag Burnishing" is burnishing the brake linings by applying and maintaining a fairly constant brake application pressure while driving against the vehicle engine power in low gear, at a slow travel speed - until a specified brake drum temperature is reached. The brakes are then released and allowed to cool (by driving vehicle around) before repeating another drag. Enough apply pressure is used to accomplish a vehicle travel speed of 4 -8 mph.

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Asbestos and Non-Asbestos Fibers



ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from Meritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. **Separate Work Areas.** Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

**DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.**

2. **Respiratory Protection.** Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.
3. **Procedures for Servicing Brakes.**
 - a) Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.
 - b) As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
 - c) If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.
 - d) Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.
 - e) **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.
4. **Cleaning Work Areas.** Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.
5. **Worker Clean-Up.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.
6. **Waste Disposal.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.



NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from Meritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some medical experts believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

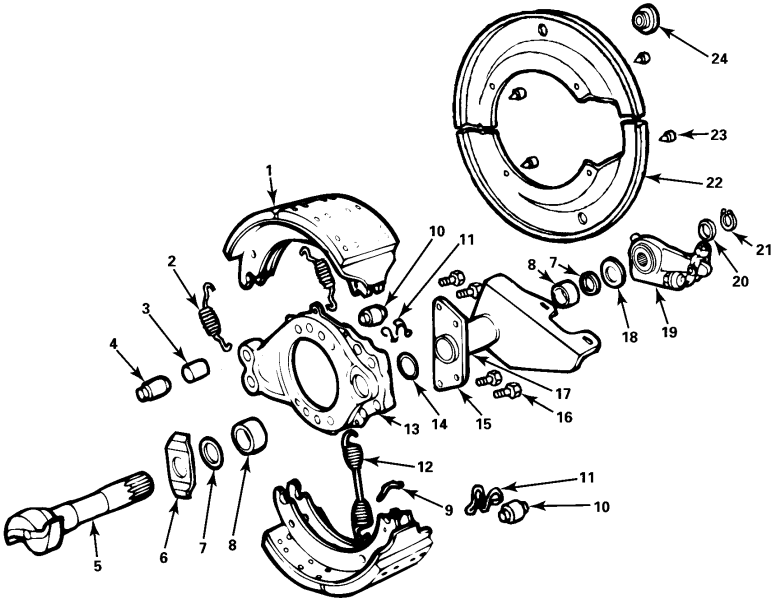
Recommended Work Practices

1. **Separate Work Areas.** Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.
 2. **Respiratory Protection.** OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m³ as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.
- Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.
3. **Procedures for Servicing Brakes.**
 - a) Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.
 - b) As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
 - c) If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
 - d) Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.
 - e) **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.
 4. **Cleaning Work Areas.** Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.
 5. **Worker Clean-Up.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.
 6. **Waste Disposal.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

Section 1 **Exploded Views**

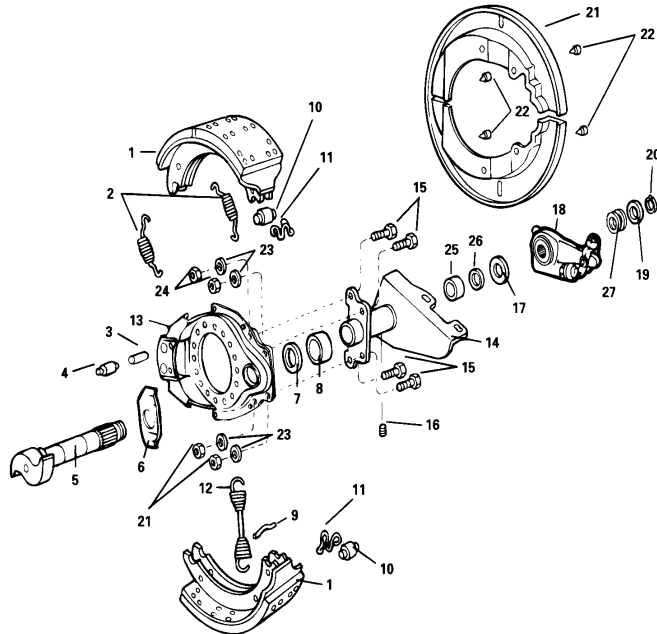


15-Inch Q Plus™
16.5-Inch Q Plus™ and Q Series Brakes with Cast Spiders

Item	Description
1	Shoe and Lining Assembly
2	Spring - shoe retaining
3	Bushing - anchor pin
4	Anchor Pin - brake shoe
5	Camshaft - "S" head
6	Washer - camhead
7	Seal - camshaft (grease)
8	Bushing - camshaft
9	Pin - return spring
10	Roller - brake shoe
11	Retainer - shoe roller
12	Spring - brake shoe return

Item	Description
13	Cast spider - brake
14	Seal - chamber bracket
15	Bracket - camshaft and chamber
16	Capscrew - chamber bracket
17	Fitting - grease
18	Washer - camshaft (thick)
19	Slack Adjuster - automatic
20	Washer - spacing
21	Snap Ring - camshaft
22	Dust Shield
23	Capscrew - dust shield
24	Plug

Section 1 Exploded Views

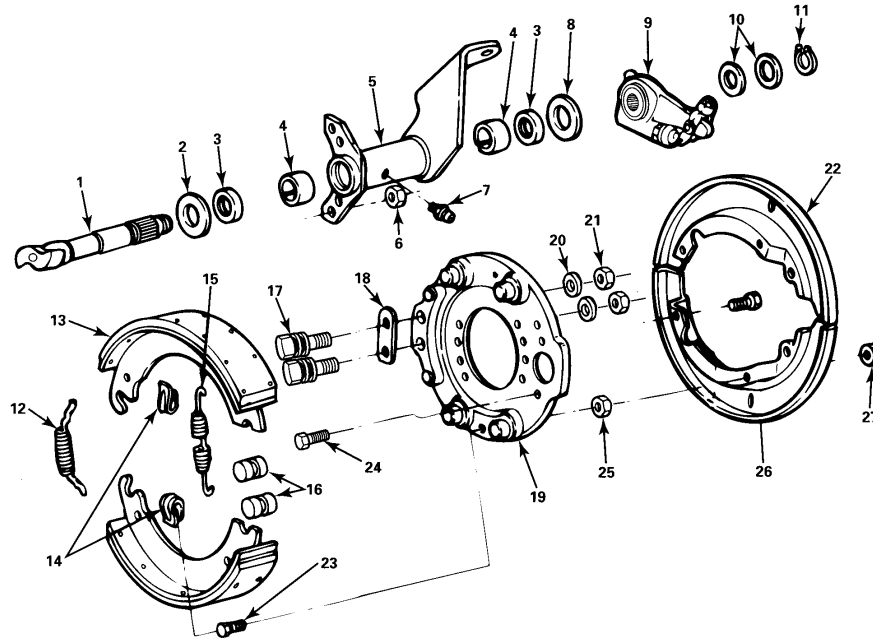


16.5-Inch Q Plus™ Brakes with Stamped Spiders

Item	Description
1	Shoe and Lining Assembly
2	Spring - shoe retaining
3	Bushing - anchor pin
4	Anchor Pin - brake shoe
5	Camshaft - "S" head
6	Washer - camhead
7	Orange seal - camshaft
8	Bushing - camshaft
9	Pin - return spring
10	Roller - brake shoe
11	Retainer - shoe roller
12	Spring - brake shoe return
13	Stamped spider - brake
14	Bracket - camshaft and chamber

Item	Description
15	Capscrew - Grade 8
16	Plug - pipe
17	Washer - camshaft (thick)
18	Slack adjuster - automatic
19	Washer - spacing
20	Snap ring - camshaft
21	Dust shield
22	Cap screw - dust shield
23	Washer (4) - hard
24	Nut (4) - Grade 8
25	Bushing - camshaft
26	Seal - camshaft
27	Washer - spacing (thin)

Section 1 Exploded Views

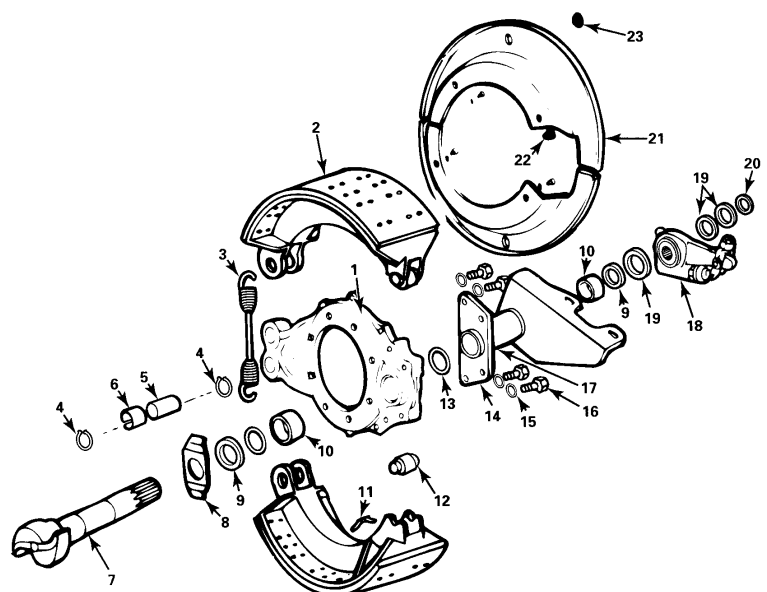


15-Inch Q Series Brakes

Item	Description
1	Camshaft
2	Washer - camhead
3	Seal - camshaft (grease)
4	Bushing - camshaft
5	Bracket - camshaft
6	Nut - camshaft bracket
7	Grease Fitting
8	Washer - spacing
9	Slack Adjuster - automatic
10	Spacers - camshaft
11	Snap Ring - camshaft
12	Spring - shoe retaining
13	Shoe and Lining Assembly
14	Clips - anti-rattle

Item	Description
15	Spring - shoe return
16	Rollers - brake shoe
17	Anchor Pins - brake shoe
18	Plate - support
19	Backing Plate
20	Washer - anchor pin
21	Nut - anchor pin
22	Dust Shield
23	Bolt - shoe clip
24	Bolt - camshaft bracket
25	Nut - clip to backing plate
26	Capscrew - dust shield
27	Nut - dust shield

Section 1
Exploded Views

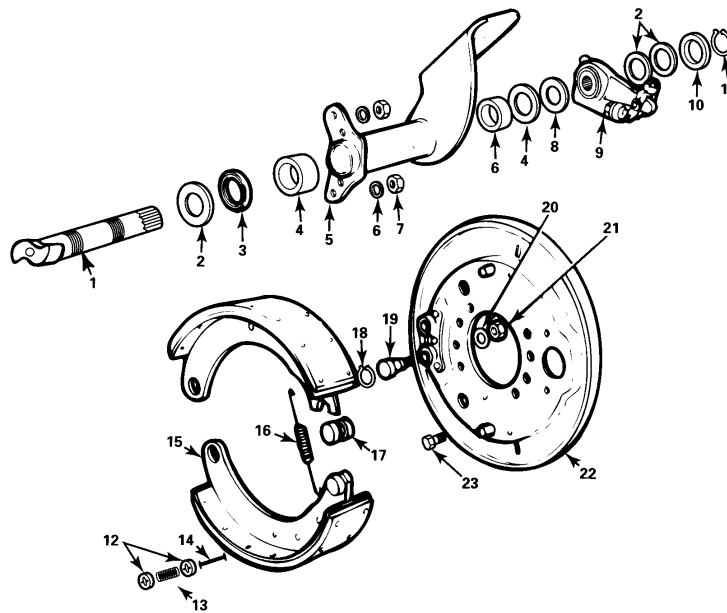


16.5-Inch P Series Brakes

Item	Description
1	Spider - brake
2	Shoe and Lining Assembly
3	Spring - brake shoe return
4	Snap Ring - anchor pin
5	Anchor Pin - brake shoe
6	Bushing - anchor pin
7	Camshaft - "S" head
8	Washer - camhead
9	Seal - camshaft (grease)
10	Bushing - camshaft
11	Pin - return spring
12	Roller - cam

Item	Description
13	Seal - camshaft bracket
14	Bracket - camshaft and chamber
15	Washer - bracket cap screw
16	Cap screw - camshaft bracket
17	Fitting - grease
18	Slack Adjuster - automatic
19	Washer - spacing
20	Snap Ring - camshaft
21	Dust Shield
22	Cap screw - dust shield
23	Plug

Section 1 Exploded Views



15-Inch T Series Brakes

Item	Description
1	Camshaft
2	Washer - camhead
3	Seal - camshaft (grease)
4	Bushing
5	Bracket - camshaft and chamber
6	Lockwasher - bracket
7	Nut - bracket
8	Washer - spacing
9	Slack Adjuster - automatic
10	Washer - spacer
11	Snap Ring - camshaft
12	Retainer - anti-rattle spring

Item	Description
13	Spring - anti-rattle
14	Rod - anti-rattle
15	Shoe and Lining Assembly
16	Spring - shoe return
17	Roller - brake shoe
18	Snap Ring - anchor pin
19	Anchor Pin - brake shoe
20	Washer - anchor pin
21	Nut - anchor pin
22	Backing Plate
23	Capscrew - dust shield

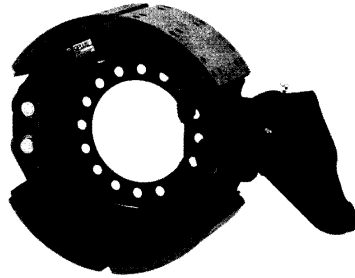
Section 2 Introduction

Q Plus™

Figure 2.1

- More lining thickness increases service life and mileage between relines.
- A redesigned S-cam and heavy-duty shoe return spring allow additional shoe travel.
- An improved camshaft bushing contributes to longer service life.
- The trailer axle version of the 16.5 x 7.0-inch Q Plus™ brake uses a heavy-duty, bolt-on camshaft bushing.

Figure 2.1



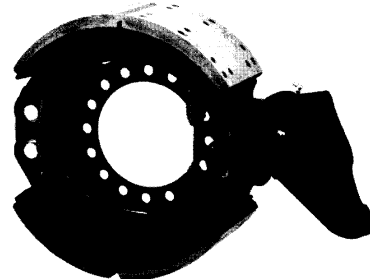
Q Plus™ LX500 and Q Plus™ MX500

Figure 2.2

For complete maintenance and service information on Meritor's Q Plus™ LX500 and MX500 cam brakes, refer to Maintenance Manual No. MM-96173, *Q Plus™ LX500 and MX500 Cam Brakes*. To order a copy of this publication call Meritor's Customer Service Center at 800-535-5560.

- The Q Plus™ LX500 cam brake and the Q Plus™ MX500 cam brake both include an Extended Lube Feature and Meritor factory-installed automatic slack adjusters.
- The Q Plus™ MX500 cam brake also includes all features found in the LX500 plus special long life brake shoes and linings.

Figure 2.2

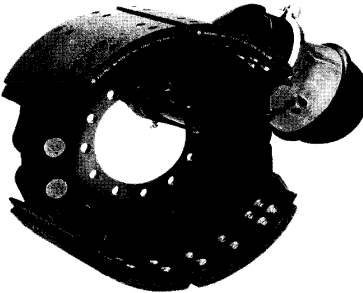


Cast Plus™

Figure 2.3

- Spec'd for heavy-duty, off-highway and people-mover applications.
- Uses Meritor's Q Plus™ cam brake linings. Providing increased service life and mileage between relines.
- A redesigned S-cam and heavy-duty shoe return spring allow additional shoe travel.
- An improved camshaft bushing contributes to longer service life.
- Uses Meritor's Cast P Series brake shoe design.

Figure 2.3



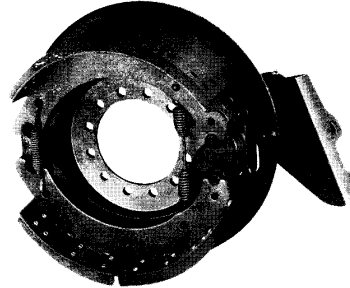
Section 2 Introduction

Q Series Brakes

Figure 2.4

- Open anchor pins for “Quick Change” service.
- Single web shoe (15-inch only).
- Two shoe retainer springs in addition to the shoe return springs.
- Available in 16.5-inch diameter with 5, 6, 7, 8.625 and 10-inch widths with 0.75-inch tapered brake lining.
- Available in 15.0-inch diameter for front non-drive axle applications.

Figure 2.4

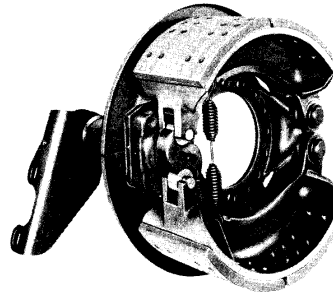


P Series

Figure 2.5

- 16.5-inch and 18-inch diameters with 7-inch wide cast shoes.
- 0.75-inch tapered brake lining.

Figure 2.5

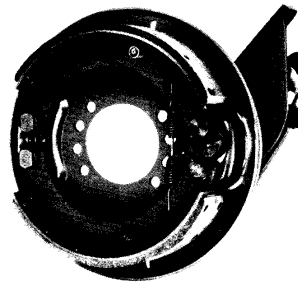


T Series

Figure 2.6

- 15-inch diameter with 3.5-inch and 4-inch widths for smaller capacity axles.
- 0.438-inch thick lining.

Figure 2.6



Section 2 Introduction

Differences Between Q Plus™ and Q Series Cam Brakes

Q Plus™ Components	Q Series Components
<p>FMSI NO. 4707 PLUS-SHAPED HOLES (+) STAMPED IN TABLE</p> <p>28 RIVET HOLES IN TABLE</p> <p>NO BULGE ON WEB</p> <p>MERITOR 16.5 Q PLUS™</p> <p>16.5 Q PLUS™ STAMPED ON WEB</p> <p>SHOE TAG</p> <p>16.5" X 7" Q PLUS™ SHOE</p>	<p>32 RIVET HOLES IN TABLE</p> <p>FMSI NO. 4515G</p> <p>BULGE ON WEB</p> <p>MERITOR 16.5 Q SERIES</p> <p>16.5 Q SERIES STAMPED ON WEB</p> <p>SHOE TAG</p> <p>16.5" X 7" Q SHOE</p>
<p>CAM TIP TO TIP = 4.25"</p> <p>PART NUMBER LOCATED HERE</p> <p>DEEPER POCKET</p> <p>1.18 DIA.</p> <p>16.5 Q PLUS™ LOCATED HERE</p> <p>INCREASED LIFT</p> <p>16.5" Q PLUS™ CAMSHAFT (1.5" DIA.-28 SPLINES)</p>	<p>CAM TIP TO TIP = 4.22"</p> <p>PART NUMBER LOCATED HERE</p> <p>1.378 DIA.</p> <p>16.5" Q CAMSHAFT (1.5" DIA.-10 OR 28 SPLINES)</p>
<p>FMSI NO. 4702 USED WITH SPIDER</p> <p>16 RIVET HOLES IN TABLE</p> <p>NO BULGE ON WEB</p> <p>MERITOR 15 Q PLUS™</p> <p>15 Q PLUS™ STAMPED ON WEB</p> <p>DOUBLE WEB</p> <p>15" X 4" Q PLUS™ SHOE</p>	<p>FMSI NO. 1308</p> <p>USED WITH BACKING PLATE</p> <p>14 RIVET HOLES IN TABLE</p> <p>BULGE ON WEB SINGLE WEB</p> <p>MERITOR 15 Q PLUS™</p> <p>15 Q PLUS™ STAMPED ON WEB</p> <p>15" X 4" Q SHOE</p>
<p>CAM TIP TO TIP = 3.38"</p> <p>PART NUMBER LOCATED HERE</p> <p>DEEPER POCKET</p> <p>0.988 DIA.</p> <p>16 Q PLUS™ LOCATED HERE</p> <p>INCREASED LIFT</p> <p>15" Q PLUS™ CAMSHAFT (1.5" DIA.-28 SPLINES)</p>	<p>CAM TIP TO TIP = 3.25"</p> <p>PART NUMBER LOCATED HERE</p> <p>1.164 DIA.</p> <p>15" Q CAMSHAFT (1.25" DIA.-10 OR 24 SPLINES)</p>

Camshafts	Shoes	Return Springs
Q Plus™	Q Plus™	Heavy-duty (blue)
Q Plus™	Q Series	Standard
Q	Q Series	Standard

Section 3 Disassembly

Remove the Wheel Components

Asbestos and Non-Asbestos Fibers Warning

Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance and service.

WARNING

Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip or fall over. Serious personal injury can result.

1. The vehicle must be on a level surface.
2. Put blocks under the wheels that will not be raised to keep the vehicle from moving.
3. Raise the vehicle, so that the area you will service is off of the ground. Support the vehicle with safety stands.

WARNING

When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

4. If the brake has spring chambers, carefully cage and lock the spring, so that the spring cannot actuate during assembly.

Automatic Slack Adjuster

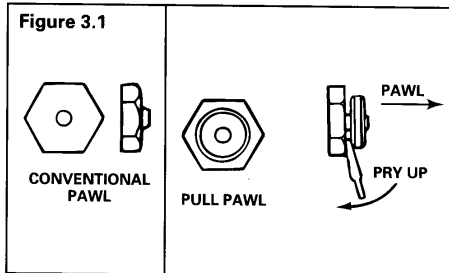
For complete maintenance and service information on Meritor's automatic slack adjuster, refer to Maintenance Manual No. 4B, *PayMaster® Automatic Slack Adjuster*. To order a copy of this publication, call Meritor's Customer Service Center at 800-535-5560.

CAUTION

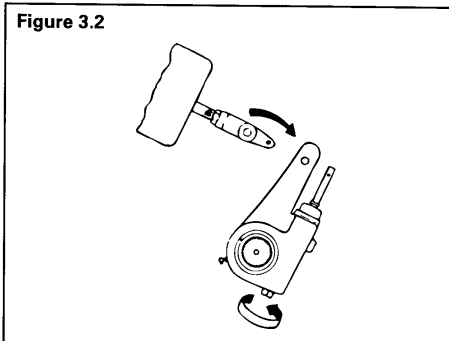
You must disengage a pull pawl or remove a conventional pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust brake clearance. Replace damaged pawls before putting the vehicle in service.

1. If the slack adjuster is equipped with a conventional pawl: Remove the pawl. Figure 3.1.

If the slack adjuster is equipped with a pull pawl assembly: Use a screwdriver or an equivalent tool to lift the pawl button at least 1/32-inch from the actuator to disengage the pawl. Figure 3.1.



2. Use a wrench to turn the manual adjusting nut in the direction shown in Figure 3.2 until the brake shoes are fully retracted and the drum clears the lining.



Section 3 Disassembly



WARNING

When you remove a clevis pin that has a spring, hold the spring with pliers. The spring can disengage from the clevis with enough force to cause serious personal injury.

3. Remove both clevis pins and retainer clips or cotter pins.
4. Move the slack adjuster away from the clevis.
5. Follow the manufacturer's instructions to remove the wheel and drum from the axle.

Brake Shoes

All Q Plus™ and Q Series 15-Inch and 16.5-Inch Brakes

1. Push **DOWN** on the **BOTTOM** brake shoe. Pull on the cam roller retainer clip to remove the **BOTTOM** cam roller. **Figure 3.3.**
2. Lift the **TOP** brake shoe and pull on the cam roller retainer clip to remove the **TOP** cam roller.
3. Lift the **BOTTOM** shoe to release the tension on the brake shoe return spring. **Figure 3.4.**
4. Rotate the **BOTTOM** shoe to release the tension on the brake shoe retainer springs. **Figure 3.5.**
5. Remove the shoe retainer springs and the brake shoes.

Figure 3.3

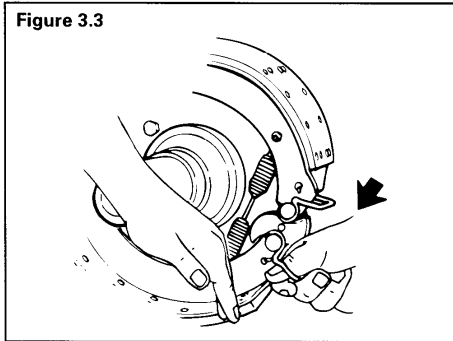


Figure 3.4

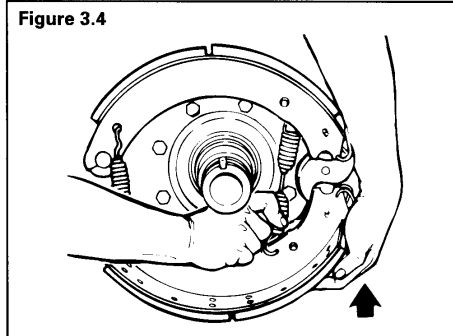
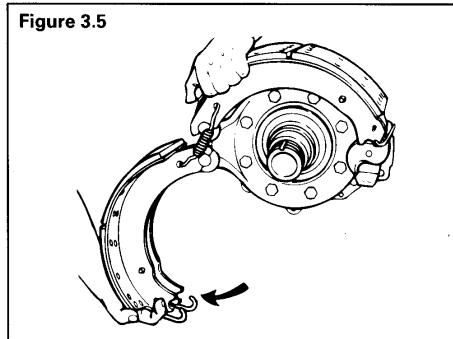


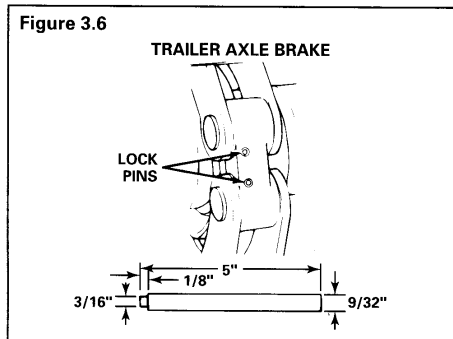
Figure 3.5



Section 3 Disassembly

P Series and Cast Plus™ Brakes

NOTE: Some trailer axle P Series brakes have anchor pins that are held in place with lock pins. You can use a steel rod to make a tool to drive out the lock pins. **Figure 3.6.**



NOTE: The current anchor pin arrangement is shown in **Figure 3.7**. Older P Series brakes can include additional parts.

1. Remove the anchor pin snap ring, washer, retainer, felts, seals or capscrews as required.



WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

2. Remove the **TOP** anchor pin with a brass drift. **Figure 3.8.**
3. Rotate the **TOP** shoe to release the tension on the brake shoe return spring. Remove the shoe. **Figure 3.9.**
4. Remove the **BOTTOM** anchor pin. Refer to Step 2, above. Remove the **BOTTOM** shoe.

Figure 3.7

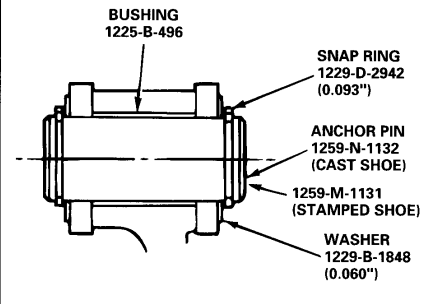


Figure 3.8

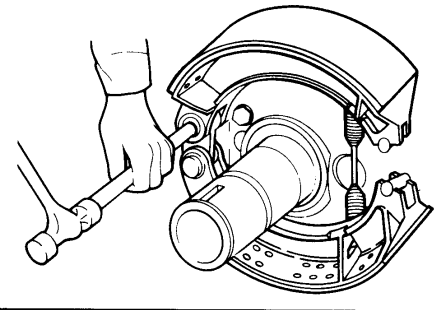
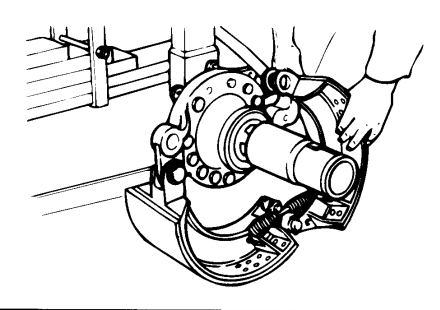


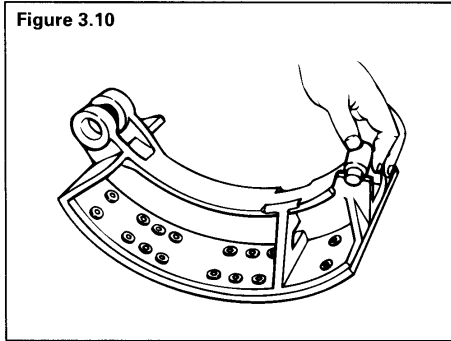
Figure 3.9



Section 3 Disassembly

5. If necessary, remove the cam rollers.
Figure 3.10.

Figure 3.10



T Series Cam Brake

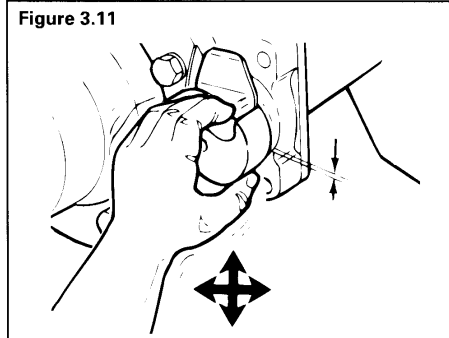
1. Remove the anti-rattle spring retainer and spring from the anti-rattle rod.
2. Push **DOWN** on the **BOTTOM** brake shoe to provide enough clearance to remove the **BOTTOM** cam roller. Remove the roller.
3. Lift the **TOP** brake shoe. Remove the **TOP** cam roller.
4. Remove the anchor pin snap ring and the anchor pin.
5. Rotate the **BOTTOM** shoe to release the tension on the brake shoe retainer springs.
6. Remove the shoe retainer springs and the brake shoes.

Remove the Camshaft and Automatic Slack Adjuster

NOTE: Meritor recommends that you check camshaft bushing end play at every reline to verify that end play is within specification.

1. At the first reline, inspect the cam-to-bushing radial free play and axial end play. Radial free play movement must be less than 0.030-inch (0.762 mm). **Figure 3.11.**

Figure 3.11



- If radial free play movement is less than 0.030-inch (0.76 mm): Do not replace the bushings and seals.
 - If radial free play movement exceeds 0.030-inch (0.76 mm): Replace the bushings and seals.
 - If axial end play exceeds 0.030-inch (0.76 mm): Remove the snap ring. Add the appropriate number of spacing washers between the automatic slack adjuster and the snap ring to achieve between 0.005-inch and 0.030-inch (0.127-0.762 mm) axial free play movement.
2. Remove the snap ring, washers and spacers from the camshaft.
 3. If the slack adjuster is equipped with a "Quick Connect" clevis: Remove the clevis from the push rod if the gap between the clevis and the clevis collar exceeds 0.060-inch (1.52 mm). You do not have to remove the clevis if it is in good condition.
 4. Remove the slack adjuster from the camshaft.
 5. Remove the camshaft from the spider.
 6. Use the correct size driver to remove the camshaft bushings from the spider and the spider bracket.

Section 4

Prepare Parts for Assembly

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's product instructions and these procedures:

- *Wear safe eye protection.*
- *Wear clothing that protects your skin.*
- *Work in a well-ventilated area.*
- *Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.*
- *You must use hot solution tanks or alkaline solutions correctly. Follow the manufacturer's instructions carefully.*

CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.

Clean and Dry Parts

1. Use soap and water to clean non-metal parts.
2. Use soft paper or cloth that is free from dirt, oil or abrasives to dry the parts completely.
3. Dry parts immediately after cleaning with clean paper or rags, or compressed air.

Corrosion Protection

NOTE: Parts must be clean and dry before you lubricate them.

1. **If you assemble parts immediately after you clean them:** Lubricate parts with grease to prevent corrosion. Parts must be clean and dry before you lubricate them.
2. **If you store parts after you clean them:** Apply a corrosion-preventive material. Store parts in a special paper or other material that prevents corrosion.

Inspect Parts

It is important to carefully inspect all parts before assembly. Check all parts for wear or damage. Repair or replace them as required.

1. Check the spider for expanded anchor pin holes and for cracks. Replace damaged spiders and anchor pin bushings.
2. Check the camshaft bracket for broken welds, cracks and correct alignment. Replace damaged brackets.
3. Check anchor pins for corrosion and wear. Replace damaged anchor pins.
4. Check brake shoes for rust, expanded rivet holes, broken welds and correct alignment. Replace a shoe with any of the above conditions.

On 16.5-inch brake shoes only: Anchor pin holes must not exceed 1.009-inches (25.63 mm) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 12.779-inches (32.46 cm). Replace any shoe with measurements that do not meet specifications.

5. Check the camshaft for cracks, wear and corrosion. Check the cam head, bearing journals and splines. Replace damaged camshafts.

WARNING

Do not operate the vehicle with the brake drum worn or machined beyond the discard dimension indicated on the drum. The brake system may not operate correctly. Damage to components and serious personal injury can result.

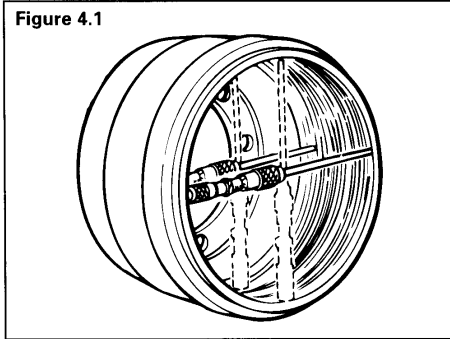
6. Check the drums:
 - a. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting and distortion. Replace drums as required. Meritor recommends that you do **NOT** turn or rebore brake drums because it decreases the strength and heat capacity of the drum.
 - b. Measure the inside diameter of the drum in several locations with a drum caliper or internal micrometer. **Figure 4.1.** Replace the drum if the diameter exceeds the specifications supplied by the drum manufacturer.

Section 4

Prepare Parts for Assembly

7. Check dust shields for rust and distortion. Repair or replace damaged shields as necessary.

Figure 4.1



Automatic Slack Adjuster

1. For slack adjusters with a "Quick Connect" clevis: Check the gap between the clevis and the collar. If the gap exceeds 0.060-inch (1.52 mm), replace the clevis with a one-piece threaded clevis design.
2. Check the clevis pins and the bushing in the arm of the slack adjuster. Replace the pins if they are worn. Replace the bushing if its diameter exceeds 0.531-inch (13.5 mm).



CAUTION

You must disengage a pull pawl or remove a conventional pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust brake clearance. Replace damaged pawls before putting the vehicle in service.

3. Use a torque wrench that measures lb-in.

4. To turn the adjusting nut in the direction shown in **Figure 4.2**, read the torque scale and rotate the gear 360 degrees (22 turns of the wrench).

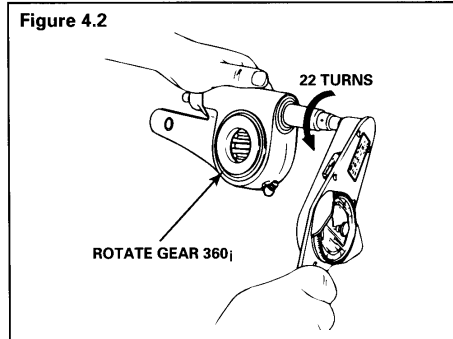
The torque value must remain less than 25 lb-in (2.83 N·m) during the complete 360-degree rotation of the gear. **1**

If the torque value remains less than 25 lb-in (2.8 N·m): The slack adjuster is working correctly.

If the torque value exceeds 25 lb-in (2.8 N·m): The slack adjuster is not working correctly. Disassemble the slack adjuster.

- Check that the slack adjuster is assembled correctly.
- Check that parts are aligned correctly.

Figure 4.2



NOTE: Do not seal the boot to the tapered part of the actuator rod.

- **If the rod has a groove:** The top of the boot must fit into the groove.
 - **If the rod does not have a groove:** Use silicone sealant to seal the top of the boot to the round part of the rod.
5. Fasten the bottom of the boot to the housing with a retaining clamp.
 6. **Conventional Pawl:** Install the pawl assembly into the housing. Tighten the capscrew to 15-20 lb-ft (20-27 N·m). **1**
 7. **Pull Pawl:** Remove the screwdriver or equivalent tool. The pull pawl will re-engage automatically.


Section 4

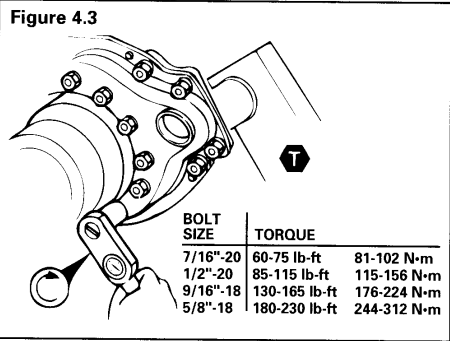
Prepare Parts for Assembly

- 8. Use a grease gun to lubricate the slack adjuster through the grease fitting. If necessary, install a camshaft into the slack adjuster gear to minimize grease flow through the gear holes.
- 9. Apply lubrication that meets Meritor's specifications until new grease purges from around the camshaft splines and from the pawl assembly. Refer to Section 8.

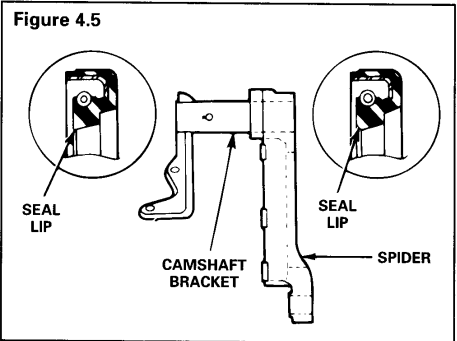
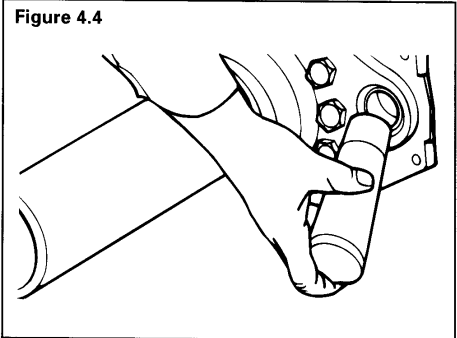
Brake Camshafts


NOTE: Meritor recommends that you install new camshaft bushings whenever you install a new camshaft.

- 1. Tighten all of the spider bolts to the correct torque as shown in **Figure 4.3**. 



- 2. Use a seal driver to install new camshaft seals and new bushings in the cast spider and the camshaft bracket. If equipped with a stamped spider, install both bushings into the bracket. **Figure 4.4.** Install the seals with the seal lips **TOWARD** the automatic slack adjuster. **Figure 4.5.**



- 3. **If the camshaft bracket was removed:** Install the chamber bracket seal and bracket onto the spider. Tighten the capscrews to the torque specified in the "Fastener Torque Table for Cam Brakes" in Section 11. 

Section 5 Assembly

Install the Camshaft

**⚠ Asbestos and Non-Asbestos
Fibers Warning**

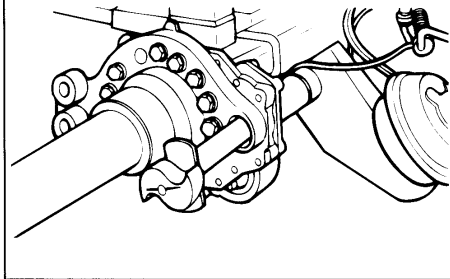
Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

1. Install the cam head thrust washer onto the camshaft. Apply O-617-A or O-617-B grease to the camshaft bushings and journals.
2. Install the camshaft through the spider and bracket so that the camshaft turns freely by hand. **Figure 5.1.**

Figure 5.1



Q Series 16.5-Inch Cam Brake

Replacing a Q Series Camshaft with Q Plus™ Camshaft in all Front and Drive Axle 16.5-Inch Q Series Brakes

Meritor has implemented a replacement of the Q Series camshaft with the Q Plus™ camshaft in all 16.5-inch Q Series brakes. Q Series brake installation and maintenance procedures are not affected by the replacement.

Replacing a Hammerclaw Camshaft with a Standard Q Plus™ Camshaft on Front Axles Only

⚠ WARNING

Do not use the straight-center bar shoe return spring with the Q Plus™ camshaft. The shoe spring can interfere with the camshaft and affect braking performance. Serious personal injury can result.

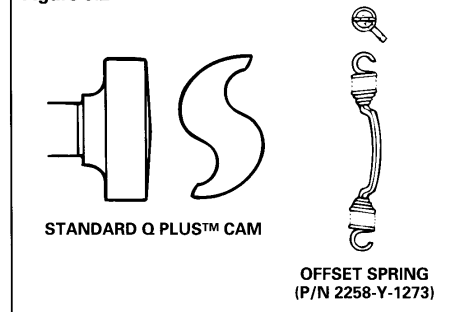
⚠ CAUTION

Only install a Q Plus™ camshaft in a Q Plus™ brake. A Q Series hammerclaw camshaft will not provide enough clearance between the brake shoe and the brake drum. Brake drag and damage to components can result.

To install a new brake drum so that it fits correctly over a Q Plus™ brake shoe, you must install a Q Plus™ camshaft. Damage to components can result.

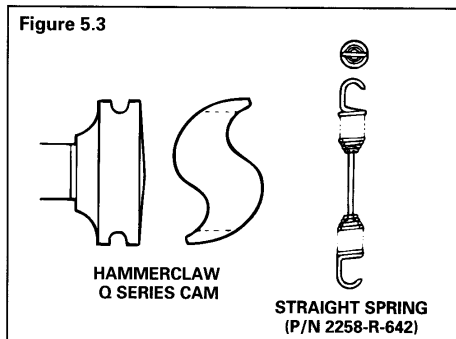
A standard Q Plus™ camshaft and a shoe return spring with an offset center bar replaces the hammerclaw Q Series camshaft and shoe return spring with a straight center bar on 16.5 x 5-inch and 6-inch Q Series cam brake. **Figure 5.2** and **Figure 5.3.**

Figure 5.2



Section 5 Assembly

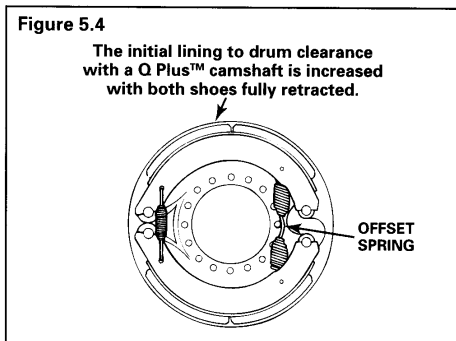
Figure 5.3



A Q Plus™ camshaft has deeper roller pockets than a Q Series camshaft and has "Q Plus" forged into one of the pockets. You may notice a larger gap between the brake lining and the drum after you assemble the brake shoe and shoe return spring with an offset center bar. The excess gap will be eliminated when you correctly adjust the brake. **Figure 5.4.** Refer to "Adjust the Brake" in Section 6.

1. Follow Steps 1-2 to replace a Q Series hammerclaw camshaft with a standard Q Plus™ camshaft in a 16.5-inch Q Series brake.
2. Continue to follow service and maintenance procedures for a Q Plus™ camshaft and Q Series brake.

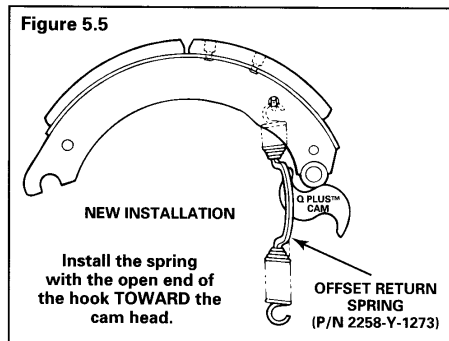
Figure 5.4



Shoe Return Spring Installation

Install the new offset shoe return spring with the open end of the spring hooks toward the camshaft. **Figure 5.5.**

Figure 5.5



Automatic Slack Adjuster

NOTE: As of January 1993 some parts of Meritor's automatic slack adjuster are no longer serviceable and are not interchangeable with parts from earlier models. Refer to Section 6 for more information.

Handed and Unhanded Automatic Slack Adjusters

There are two automatic slack adjuster designs: **HANDED** and **UNHANDED**. For most applications, install a handed automatic slack adjuster so that the pawl faces **INBOARD** on the vehicle.

The pawl can be on either side or on the front of the slack adjuster housing. **Figure 5.6.**

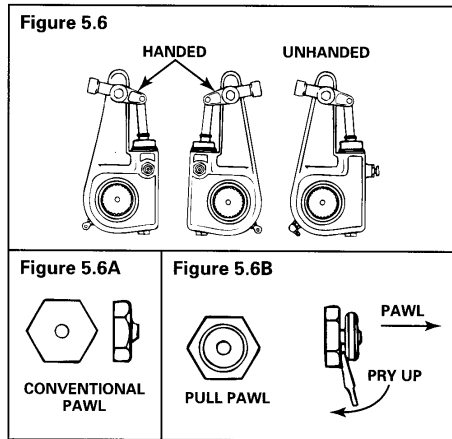
Pull Pawls

Pull pawls are spring loaded. Pry the pull pawl at least 1/32-inch to disengage the teeth. **Figure 5.6B.** When you remove the pry bar, the pull pawl will re-engage automatically.

Replace Conventional Pawls with Pull Pawls

When you service an automatic slack adjuster, replace a conventional pawl with a pull pawl. **Figures 5.6A and 5.6B.** Install the slack adjuster so that you can remove the conventional pawl or disengage the pull pawl when you adjust the brake.

Section 5 Assembly



Installing the Slack Adjuster Onto the Camshaft



WARNING

Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

1. Check the camshaft and bushings and seals for wear and corrosion.
2. Turn the camshaft by hand to check for smooth operation.
3. Repair or replace parts as required.
4. Apply the service brake and spring brake several times. Check that the chamber return spring retracts the push rod quickly and completely. If necessary, replace the return spring or the air chamber.
5. The new automatic slack adjuster must be the same length as the one you are replacing. **Table A** shows the length of slack adjuster that is used with each brake chamber size.
6. Place blocks in front of and behind the vehicle's wheels to prevent it from moving.

Table A: Chamber and Automatic Slack Adjuster Sizes

Length of Slack Adjuster (Inches)	Size of Chamber (Square Inches)
5	9*, 12*, 16, 20, 24, 30
5-1/2	9*, 12*, 16, 20, 24, 30, 36
6	24, 30, 36
6-1/2	30, 36

* Use an auxiliary spring on slack adjusters used with these size chambers. A size 9 or 12 chamber return spring cannot supply enough spring tension to completely retract the slack adjuster.



WARNING

When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

7. If the brake has a spring brake, compress and lock the spring to completely release the brake. No air pressure must remain in the service half of the air chamber.



CAUTION

Most Meritor automatic slack adjusters manufactured after January 1990 have lubrication holes in the gear splines. Do not operate the actuator before you install the slack adjuster. Lubricant can pump through the holes and onto the splines. Damage to components can result.

8. If the automatic slack adjuster gear has a 10-tooth spline, apply anti-seize compound to the slack adjuster and cam splines. Use Meritor specified O-637, Southwest SA 8249496 or equivalent lubricants.

NOTE: Install the slack adjuster so that you can remove a conventional pawl or disengage a pull pawl when you adjust the brake.

9. Install the slack adjuster onto the camshaft. Position the slack adjuster so that you can remove the pawl when you adjust the brake.
10. If necessary, install spacing washers and the snap ring at a maximum clearance of 0.062-inch (1.57 mm).
11. Install the clevis onto the push rod. Do not tighten the jam nut against the clevis.

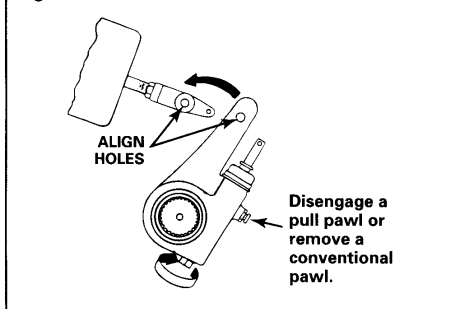
Section 5 Assembly

CAUTION

You must disengage a pull pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust the brake clearance. Replace damaged pawls before returning the vehicle to service.

- Disengage the pawl. Turn the manual adjusting nut to align the holes in the slack adjuster arm and the clevis. **Figure 5.7.**

Figure 5.7



Install the Clevis

A Slack Adjuster with a Welded Clevis

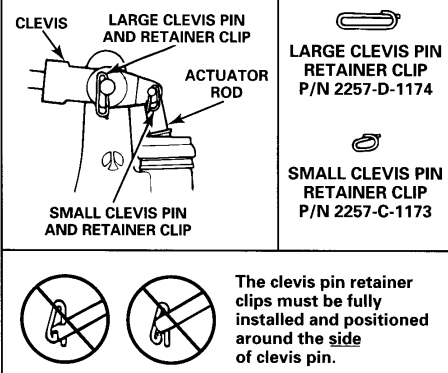
CAUTION

Always replace used clevis pin retainer clips with new ones when servicing the automatic slack adjuster or chamber. Do not reuse clevis pin retainer clips after removing them. Discard used clips. When removed for maintenance or service, clevis pin retainer clips can be bent or "gapped apart" and can lose retention. Damage to components can result.

- Check the clevis position. Apply anti-seize compound to the two clevis pins. Install the clevis pins through the clevis and the slack adjuster.

- Install new cotter pins or clevis pin retainer clips to hold the clevis pins in place. **Figure 5.8.**

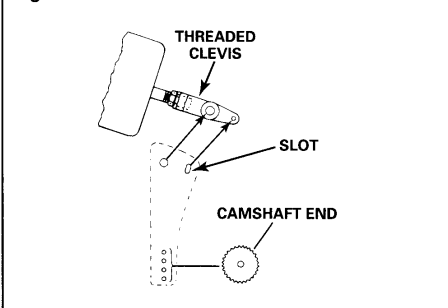
Figure 5.8



A Slack Adjuster with a Threaded Clevis

- Install the large clevis pin through the large holes in the template and the clevis.
- Select the hole in the template that matches the length of the slack adjuster. Hold that hole on the center of the camshaft.
- Look through the slot in the template. If necessary, adjust the position of the clevis until the small hole in the clevis is completely visible through the template slot. **Figure 5.9.**

Figure 5.9



Section 5 Assembly

4. Check for these specifications:
 - Thread engagement between the clevis and the push rod must be at least 1/2-inch (12.7 mm). **Figure 5.10.**
 - The push rod must not extend through the clevis more than 1/8-inch (3.18 mm). If necessary, cut the push rod, or install a new push rod with a new air chamber.
5. Tighten the jam nut against the clevis to torque specifications in **Table B.**

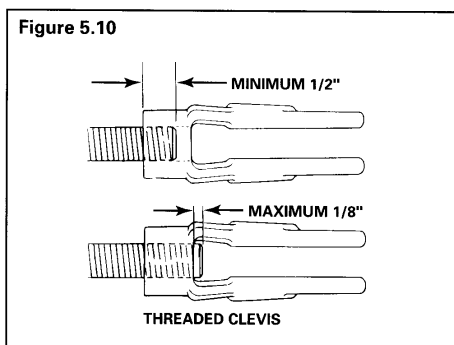

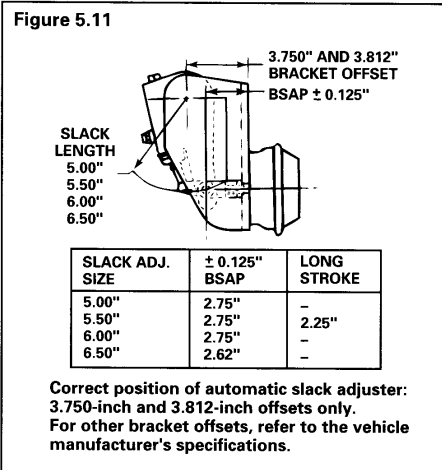


Table B: Jam Nut Torque Specifications

Threads	Torque 
1/2-20	20-30 lb-ft (27-41 N•m)
5/8-18	35-50 lb-ft (48-68 N•m)

Brake Slack Adjuster Position (BSAP) Method

When installing the automatic slack adjuster, verify that the BSAP dimension of the chamber matches the table in **Figure 5.11.**



Section 5 Assembly

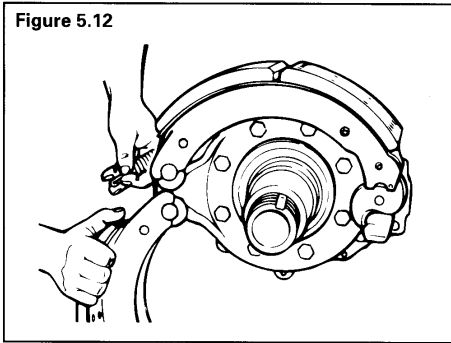
Install the Brake Shoes

NOTE: To help ensure maximum lining life, Meritor recommends that you replace springs, rollers, anchor pins and cam bushings at each reline.

All Q Plus™ and Q Series 16.5-Inch Brakes

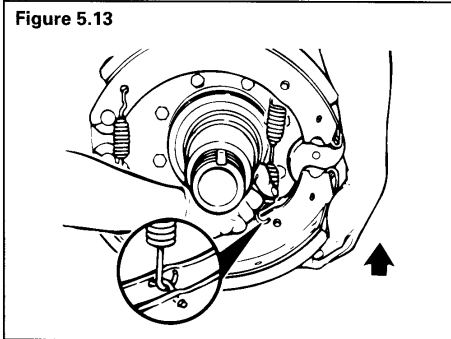
1. Place the **UPPER** brake shoe into position on the **TOP** anchor pin. Hold the **LOWER** brake shoe on the **BOTTOM** anchor pin. Install two new brake shoe retaining springs. **Figure 5.12.**

Figure 5.12



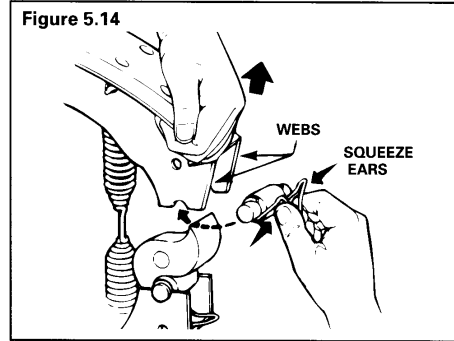
2. Rotate the **LOWER** brake shoe **FORWARD**. Install a new brake shoe return spring with the **OPEN** end of the spring hooks **TOWARD** the camshaft. **Figure 5.13.**

Figure 5.13



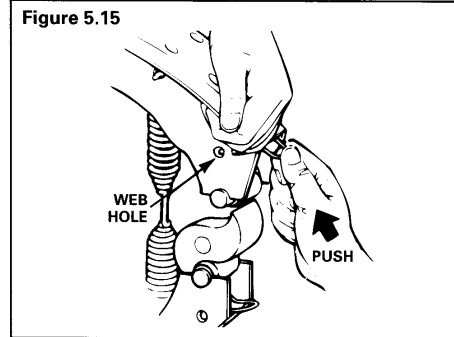
3. Pull each brake shoe **AWAY** from the cam to permit enough space to install the cam roller and cam roller retainer. Press the "ears" of the retainer to permit it to fit between the brake shoe webs. **Figure 5.14.**

Figure 5.14



4. Push the cam roller retainer into the brake shoe until its "ears" lock in the shoe web holes. **Figure 5.15.**
5. Lubricate the brake components. Refer to Section 8 for lubrication specifications.

Figure 5.15

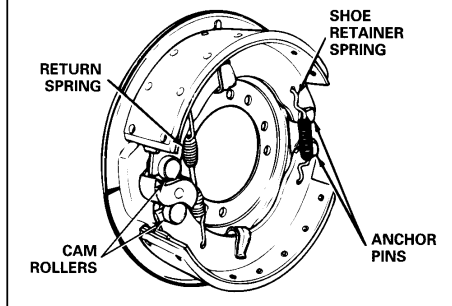


Section 5 Assembly

Q Series 15-Inch Cam Brake

1. Install the anchor pins, washers and nuts to the spider if these parts were previously removed. Tighten the anchor pin nuts to a torque of 325-375 lb-ft (441-509 N•m). **ⓘ**
2. Install a new brake shoe return spring with the **OPEN** end of the spring hooks **TOWARD** the camshaft. Install the shoes on the anchor pins. **Figure 5.16.**

Figure 5.16



3. Hold the **BOTTOM** shoe in position. Install the shoe return spring.
4. Pull the brake shoe **AWAY** from the cam to permit enough space to install the cam roller and cam roller retainer.
5. Lubricate the brake components. Refer to Section 8 for lubrication specifications.

P Series and Cast Plus™ Cam Brakes

1. Install the anchor pin bushings. If necessary, align the holes in the bushings with the holes in the spider.
2. Install a new cam roller and cam roller retainers.
3. Install the **LOWER** brake shoe in position on the spider.

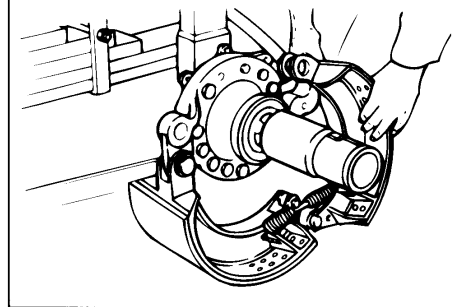


WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.


4. Use a brass drift to install the anchor pin. If necessary, align the groove on the anchor pin with the holes in the spider and bushing.
5. Install the anchor pin washers, felts, seals, retainers and snap rings if required. Install lock pins or lock screws if required. Tighten the screws to 10-15 lb-ft (13.6-20.3 N•m). **ⓘ**
6. Install a new shoe return spring on the brake shoe. **Figure 5.17.** Place the **UPPER** brake shoe into position over the spider. Repeat Steps 4 and 5.
7. Lubricate the brake components. Refer to Section 8 for lubrication specifications.

Figure 5.17



Section 5 Assembly

T Series Cam Brake

1. Install the anchor pins, washers and nuts to the backing plate if these parts were previously removed. Tighten the anchor pin nuts to 185-350 lb-ft (251-475 N•m). 
2. Install the anti-rattle rod. Install the brake shoe on the anchor pins and anti-rattle rod.
3. Install the anchor pin snap rings, the anti-rattle spring and the anti-rattle retainer spring onto the anti-rattle rod.
4. Pull the brake shoe away from the cam to permit enough space to install the shoe roller.
5. Install a new brake shoe return spring on the brake shoe.
6. Lubricate the brake components. Refer to Section 8 for lubrication specifications.

Drum and Wheel

Follow the manufacturer's instructions to install the drum and wheel onto the axle.

Section 6 Adjust the Brakes

Automatic Slack Adjuster



WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Measure the Automatic Slack Adjuster



CAUTION

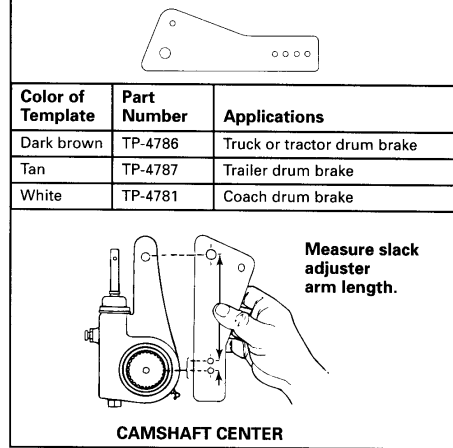
There are three Meritor automatic slack adjuster installation templates for drum brakes: Truck or tractor, trailer and coach. These templates are NOT interchangeable. You must use the correct template and adjust the clevis position as described in this section.

If you use the wrong template and install the clevis in an incorrect position, the automatic slack adjuster will not correctly adjust the brake. If the slack adjuster under-adjusts the brake, stopping distances will be increased. If the slack adjuster over-adjusts the brake, the linings can drag and damage the brake.

NOTE: For long-stroke chambers, use the Brake Slack Adjuster Position method to measure the automatic slack adjuster.

1. If necessary, order the correct automatic slack adjuster template from Meritor's Customer Service Center at 800-535-5560.
2. Use the correct Meritor automatic slack adjuster template to measure the length of the slack adjuster. The marks by the holes in the small end of the template indicate the length of the slack adjuster. **Figure 6.1.**

Figure 6.1



Adjust the Brake

Free Stroke Measurement



CAUTION

You must disengage a pull pawl or remove a conventional pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust brake clearance. Replace damaged pawls before putting the vehicle in service.

NOTE: During preventive maintenance on an in-service brake, check both the free stroke as described below and the adjusted chamber stroke as described on page 27.

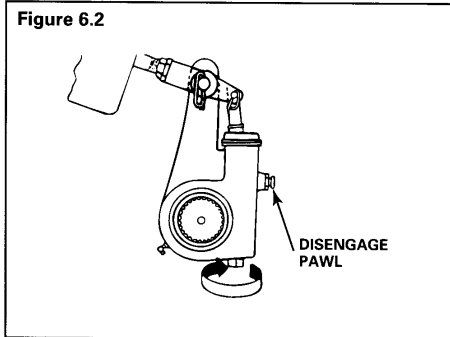
On some applications, you may find the in-service free stroke to be slightly longer than specified in Step 5. However, this is not necessarily a concern, as long as the adjusted chamber stroke is within the limits shown in the Commercial Vehicle Safety Alliance (CVSA) charts on page 28.

1. Disengage a pull pawl or remove a conventional pawl.

Section 6 Adjust the Brakes

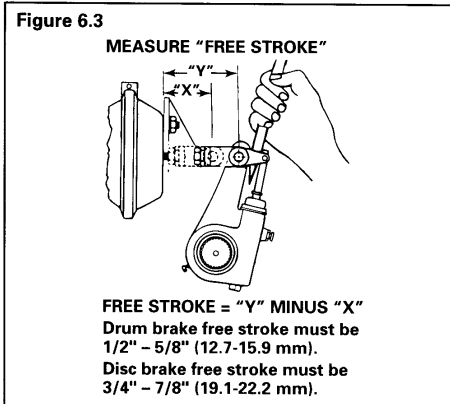
- Turn the adjusting nut in the direction shown in **Figure 6.2** until the linings touch the drum, and then turn the adjusting nut 1/2 turn in the opposite direction.

Figure 6.2



- Measure the distance from the center of the large clevis pin to the bottom of the air chamber while the brake is released. Refer to "X" in **Figure 6.3**.

Figure 6.3



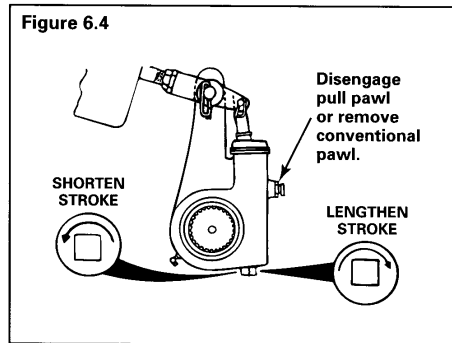
- Use a pry bar to move the slack adjuster so that the linings are against the drum (applying the brakes). Measure the same distance again while the brakes are applied. Refer to "Y" in **Figure 6.3**.

CAUTION

Do not set FREE STROKE shorter than specifications. If FREE STROKE is too short, linings can drag and damage the brake.

- The difference between measurement "X" and measurement "Y" is the free stroke, which sets the clearance between the linings and drum. Free stroke must be within 1/2-inch - 5/8-inch (12.7-15.9 mm) for drum brakes. **Figure 6.3**.
- If it is necessary to adjust the stroke, turn the adjusting nut 1/8 turn in the direction shown in **Figure 6.4** and check the stroke again. Continue to measure and adjust the stroke until it is adjusted correctly.

Figure 6.4



- Release a pull pawl or install a conventional pawl.

WARNING

When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

- If the brake has spring chambers, carefully release the spring.
- Test the vehicle to ensure that the brake system is operating correctly before you return the vehicle to service.

Section 6 Adjust the Brakes

Commercial Vehicle Safety Alliance (CVSA) Guidelines to Measure Push Rod Travel (Adjusted Chamber Stroke)

Use the following procedures to check in-service push rod travel (adjusted chamber stroke) on truck or tractor air brakes with automatic slack adjusters.

Hold the ruler parallel to the push rod and measure as carefully as possible. An error in measurement can affect CVSA re-adjustment limits, which state that "any brake 1/4-inch or more past the re-adjustment limit, or any two brakes less than 1/4-inch beyond the re-adjustment limit will be cause for rejection."



WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.



WARNING

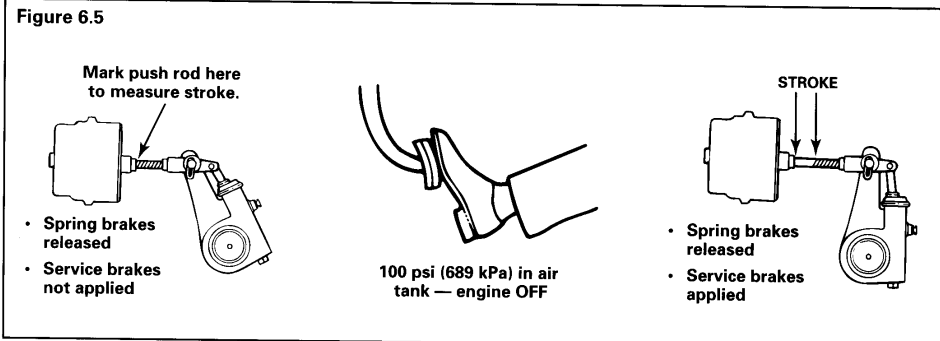
When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

1. The engine must be **OFF**. If the brake has spring chambers, carefully release the spring.
2. Check the gauges in the cab to ensure that air pressure in the tanks is 100 psi (689 kPa).
3. Determine the size and type of brake chamber you are inspecting.
4. With the brakes released, mark the push rod where it exits the chamber. **Figure 6.5**. Measure and record the distance.
5. Have another person apply and hold the brakes one full application. **Figure 6.5**.
6. Measure push rod travel distance (adjusted chamber stroke) from where the push rod exits the brake chamber to your mark on the push rod. Measure and record the distance. **Figure 6.5**.
7. **To determine push rod travel (adjusted chamber stroke):** Subtract the measurement you obtained in Step 4 from the measurement you obtained in Step 6. The difference is the push rod travel (adjusted chamber stroke).
 - a. Push rod travel (adjusted chamber stroke) must not be greater than the stroke length shown in the CVSA reference charts for the size and type of air chamber you are inspecting.
 - b. If push rod travel (adjusted chamber stroke) is greater than the maximum stroke shown in the CVSA reference charts, inspect the slack adjuster and replace it if necessary.

Alternate Method for Determining Push Rod Travel (Adjusted Chamber Stroke)

Use the above procedure, except in Step 4 and Step 6, measure the distance from the bottom of the air chamber to the center of the large clevis pin on each of the brakes.

Figure 6.5



Section 6

Adjust the Brakes

Commercial Vehicle Safety Alliance (CVSA) North American Out-of-Service Criteria Reference Charts

NOTE: A brake found at the adjustment limit is not a violation.

Table C: "Standard Stroke" Clamp-Type Brake Chamber Data

Type	Outside Diameter (inches)	Brake Adjustment Limit (inches)	
6	4-1/2	1-1/4	Should be as short as possible without lining to drum contact
9	5-1/4	1-3/8	
12	5-4/16	1-3/8	
16	6-3/8	1-3/4	
20	6-25/32	1-3/4	
24	7-7/32	1-3/4	
30	8-3/32	2	
36	9	2-1/4	

* For 3" maximum stroke type 24 chambers

Table D: "Long Stroke" Clamp-Type Brake Chamber Data

Type	Outside Diameter (inches)	Brake Adjustment Limit (inches)	
16	6-3/8	2.0	Should be as short as possible without lining to drum contact
20	6-25/32	2.0	
24	7-7/32	2.0	
24*	7-7/32	2.5	
30	8-3/32	2.5	

Section 7 Reline the Brakes

Single or Tandem Axle



WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use the Correct Lining Material

NOTE: The drums and linings on the front axle do not have to be the same as the drums and linings on the rear axle.

Use the lining material that is specified by the vehicle manufacturer to help ensure that the brake will perform as originally designed and meet Department of Transportation (DOT) performance regulations.

Single Axle

- Always reline both wheels of a single axle at the same time.
- Always install the same linings and drums on both wheels of a single axle.

Tandem Axle

- Always reline all four wheels of a tandem axle at the same time.
- Always install the same linings and drums on all four wheels of a tandem axle.

Combination Friction Linings



CAUTION

Only install combination friction linings in the correct location on a brake shoe. You must install a primary lining on a primary shoe. Carefully follow the instructions that are included with the linings to avoid damage to components. Figure 7.1.

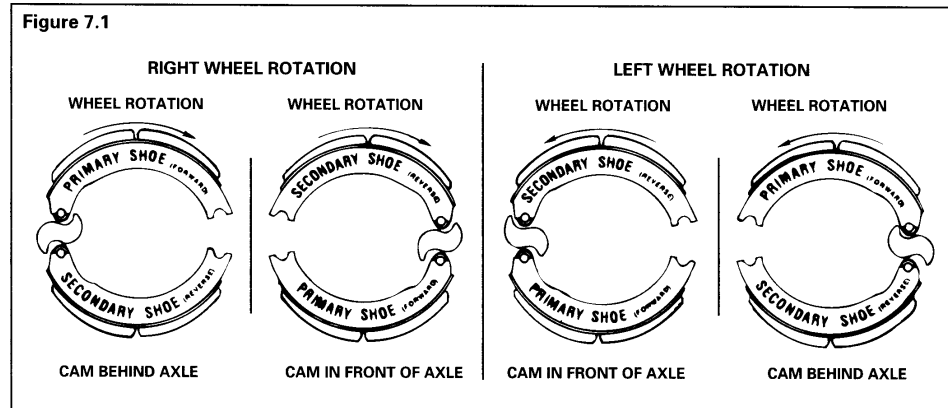
You can combine brake linings. This means that the lining set you install on the primary shoe will have a different friction rating than the lining set you install on the secondary shoe. Follow the instructions included with replacement combination linings to correctly install the primary lining on the primary shoe.

Primary Shoe Locations

The first shoe past the cam in the direction of wheel rotation is the primary shoe. Refer to Figure 7.1 to determine primary and secondary shoe locations.

1. The primary shoe can be either at the **TOP** or the **BOTTOM** position, depending on the location of the cam.
2. **If the cam is BEHIND the axle:** The **TOP** shoe is the primary shoe.
3. **If the cam is in FRONT of the axle:** The **BOTTOM** shoe is the primary shoe.

Figure 7.1



Section 8 Lubrication and Maintenance

Camshaft Bushings

NOTE: Meritor recommends that you install new camshaft bushings whenever you install a new camshaft.

1. Refer to **Table E** for grease specifications.



WARNING

If grease flows from the seal near the cam head, replace the seal. Remove any grease or oil from the cam head, rollers and linings. Always replace contaminated linings. Grease on the linings can increase stopping distances. Serious personal injury and damage to components can result.

2. Lubricate through the fitting on the bracket or spider until new grease flows from the **INBOARD** seal.

On-Highway Linehaul Applications

- Q Plus™ and Q Series brakes: Every 100,000 miles (160,000 km).
- P Series brakes: Every 50,000 miles (80,000 km) or every six months, whichever comes first.

Off-Highway Applications

- At least every four months when you replace the seals and reline the brakes.
- During the first four month period: Inspect for hardened or contaminated grease and for the absence of grease every two weeks to determine lubrication intervals.
- Lubricate more often for severe-duty applications.

Automatic Slack Adjuster Maintenance

Inspect and lubricate the slack adjuster according to one of the following schedules. Refer to **Table F** for grease specifications. Use the schedule that requires the most frequent inspection and lubrication. Also inspect and lubricate the slack adjuster whenever you reline the brakes.

- The schedule of chassis lubrication used by your fleet.
- The schedule of chassis lubrication recommended by the chassis manufacturer.
- Every six months.
- A minimum of four times during the life of the linings.

Anti-Seize Compound

1. Use anti-seize compound on the clevis pins of all slack adjusters.
2. **Conventional automatic:** Use anti-seize compound on the automatic slack adjuster and cam splines if the slack adjuster gear has no grease groove and holes around its inner diameter.

Factory-Installed Automatic Slack Adjusters on Q Plus™ LX500 and MX500 Cam Brake Packages

Q Plus™ LX500 and MX500 cam brake packages include factory-installed automatic slack adjusters that do not have grease fittings, and lubrication intervals differ from conventional slack adjusters. Refer to Maintenance Manual No. MM-96173, *Q Plus™ LX500 and MX500 Cam Brakes*, for complete information. Order this publication by calling Meritor's Customer Service Center at 800-535-5560.

Section 8 Lubrication and Maintenance

Table E: Cam Brake Grease Specifications

Components	Meritor Specification	NLGI Grade	Grease Type	Outside Temperature
<ul style="list-style-type: none"> • Retainer Clips • Anchor Pins • Rollers (Journals Only) • Camshaft Bushings <p>When the brake is disassembled, or when necessary, lubricate the anchor pins and rollers where they touch the brake shoes.</p> <p>Do not allow grease to come in contact with the part of the cam roller that touches the cam head. Refer to the WARNING, on the previous page.</p>	O-616-A	1	Clay Base	Down to -40°F (-40°C)
	O-617-A	1	Lithium 12-Hydroxy Stearate or Lithium Complex	Refer to the grease manufacturer's specifications for the temperature service limits.
	or O-617-B	2		
	O-645	2	Synthetic Oil, Clay Base	Down to -65°F (-54°C)
	O-692	1 and 2	Lithium Base	Down to -40°F (-40°C)
Camshaft Splines	Any of Above	See Above	See Above	See Above
	O-637*	1-1/2	Calcium Base	Refer to the grease manufacturer's specifications for the temperature service limits.
	O-641	—	Anti-Seize	

Table F: Automatic Slack Adjuster Grease Specifications

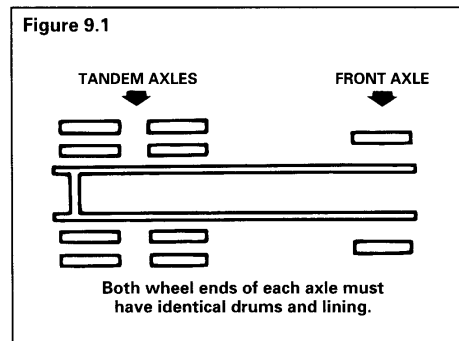
Component	Meritor Specification	NLGI Grade	Grease Type	Outside Temperature
<ul style="list-style-type: none"> • Automatic Slack Adjuster 	O-616-A	1	Clay Base	Down to -40°F (-40°C)
	O-692	1 and 2	Lithium Base	Down to -40°F (-40°C)
	O-645	2	Synthetic Oil, Clay Base	Down to -65°F (-54°C)
<ul style="list-style-type: none"> • Clevis Pins 	Any of Above	See Above	See Above	See Above
	O-637*	1-1/2	Calcium Base	Refer to the grease manufacturer's specifications for the temperature service limits.
	O-641	—	Anti-Seize	

* Do not mix Meritor grease specification O-637 (part number 2297-U-4571), a calcium-base, rust-preventive grease, with other greases. The grease is also available as "Corrosion Control" (part number SA 8249496) from Southwest Petro-Chemical Division of Witco Chemical Corporation, 1400 S. Harrison, Olathe, KS 66061.

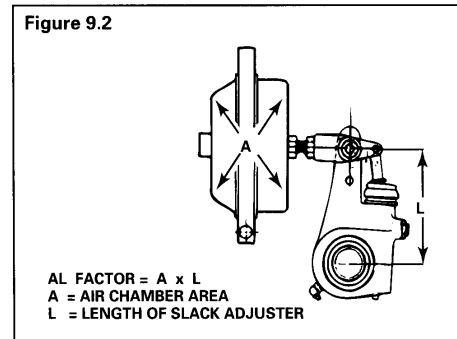
Section 9 Inspection

Before You Return the Vehicle to Service

1. Check the complete air system for worn hoses and connectors. With air pressure at 100 psi, brakes released and engine off, loss of tractor air pressure must not exceed two psi a minute. Total tractor and trailer loss must not exceed three psi per minute.
2. Check to see that the air compressor drive belt is tight. Air system pressure must rise to approximately 100 psi in two minutes.
3. The governor must be checked and set to the specifications supplied by the vehicle manufacturer.
4. Both the tractor and trailer air systems must match the specifications supplied by the vehicle manufacturer.
5. Both wheel ends of each axle must have the same linings and drums. All four wheel ends of tandem axles also must have the same linings and drums. It is not necessary for the front axle brakes to be the same as the rear driving axle brakes. **Figure 9.1.**



7. The return springs must retract the shoes completely when the brakes are released. Replace the return springs each time the brakes are relined. The spring brakes must retract completely when they are released.
8. The air chamber area multiplied by the length of the automatic slack adjuster is called the "AL" factor. This number must be equal for both ends of a single axle and all four ends of a tandem axle. **Figure 9.2.**



6. Always follow the specifications supplied by the vehicle manufacturer for the correct lining to be used. Vehicle brake systems must have the correct friction material and these requirements can change from vehicle to vehicle.

Section 10

Recommended Periodic Service

Recommended Periodic Service



WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.



CAUTION

Do not let brake lining wear to the point that the rivets or bolts touch the drum. Damage to the drum will occur.

Adjust

1. Correctly adjust the wheel bearings before you adjust the brakes.
2. Clean, inspect and adjust the brakes every time you remove a wheel hub.
3. Adjust the brakes when the chamber stroke exceeds the limits shown in the tables in Section 6.
4. Adjust the brakes as frequently as necessary for correct, safe operation.
5. When you adjust the brakes, check for correct lining-to-drum clearance, push rod travel and balance between the brakes.

Lubricate

Lubricate the brake and automatic slack adjuster according to the schedules on page 31.

Reline

1. To help ensure maximum lining life, Meritor recommends that you replace springs, rollers, cam bushings and anchor pins at each relining.
2. Reline the brake when the lining thickness is 0.25-inch (6.3 mm) at the thinnest point.
3. Replace shoe retainer springs, check the drum and perform a major inspection.

Inspect

Refer to Section 9 of this manual.

At a Major Overhaul

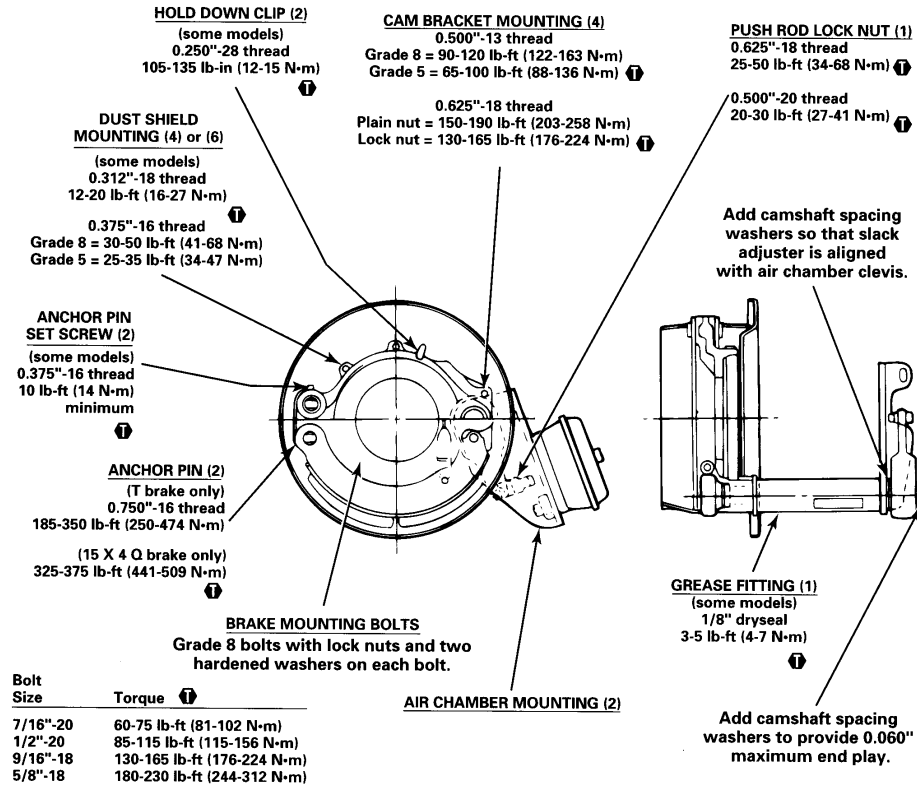
Carefully inspect the following parts when you perform a major overhaul at every second relining, or as necessary. Replace damaged or worn parts with genuine Meritor replacement parts.

1. Spiders for distortion and loose bolts.
2. Anchor pins for wear and correct alignment.
3. Brake shoes for wear at anchor pin holes or roller slots.
4. Camshafts and camshaft bushings for wear.
5. Replace shoe return springs.
6. Brake linings for grease on the lining, wear and loose rivets or bolts.
7. Drums for cracks, deep scratches or other damage.

Section 11

Torque Table

Fastener Torque Table for Cam Brakes



Grade 8 Nuts and Hard Flat Washers ①								
Chamber Size	9	12	16	20	24	30	36	Spring Chamber
Bendix	20-30 lb-ft (27-41 N•m)		30-45 lb-ft (41-61 N•m)			45-65 lb-ft (61-88 N•m)		65-85 lb-ft (88-115 N•m)
Midland	35-50 lb-ft (48-68 N•m)			70-100 lb-ft (95-136 N•m)				
MGM	35-40 lb-ft (48-54 N•m)			100-115 lb-ft (136-156 N•m)				
Anchorlok				110-115 lb-ft with hex nut and washer (149-203 N•m)				
				85-95 lb-ft with lock nut and washer (115-129 N•m)				

Section 13

Cam Brake Tips

Air Chambers

To ensure correct brake balance, all brake chambers on the same axle must be the same size and type to help ensure a balanced brake system for maximum lining wear and drum life.

Brake Kits

Meritor brake shoes, rollers, camshafts and shoe return springs are designed to perform as a system. Always install OEM spec-level components during maintenance or when you upgrade from standard to long-life brakes to help ensure correct brake performance and maximum lining life.

Cam Heads

Cam heads can look the same, but that doesn't mean they will perform the same in your brake system. Two cam head profiles can appear to be identical, but very small differences in cams from different manufacturers can be significant enough to affect the performance of your brakes. To ensure a balanced brake system and optimum lining and drum life, always install the correct replacement cam.

Cam Rollers

To avoid flat spots, lubricate a cam roller directly in the web roller pocket and not at the cam-to-roller contact area. Flat spots can affect brake adjustment and result in premature brake wear or reduced braking performance.

Drums

To help ensure balanced braking, even lining and drum wear, and correct function of the automatic slack adjuster, do not install a cast drum and a centrifuse drum on the same axle.

A cast drum and a centrifuse drum each absorbs and dissipates heat differently. When drum types and weights are mixed, different rates of heat absorption and dissipation occur that can effect the brake system.

Hardware

When you service cam brakes, replace all the springs, anchor pins, bushings and rollers — not just the shoe return springs — to help ensure maximum braking performance.

Linings

Insist on the same brand of quality OEM friction lining material to help ensure fewer relines and greater compatibility with your present system.

Replacement Parts

Always use OEM quality standard parts. Meritor brakes work as a system, and when you replace original parts with "will-fit" parts, you can compromise the performance of the entire system.

Return Springs

Replace cam brake return springs at every cam brake reline. The return spring is critical to alignment, accurate return of the brake away from the drum and correct automatic slack adjustment.

Trailer Cam Brakes

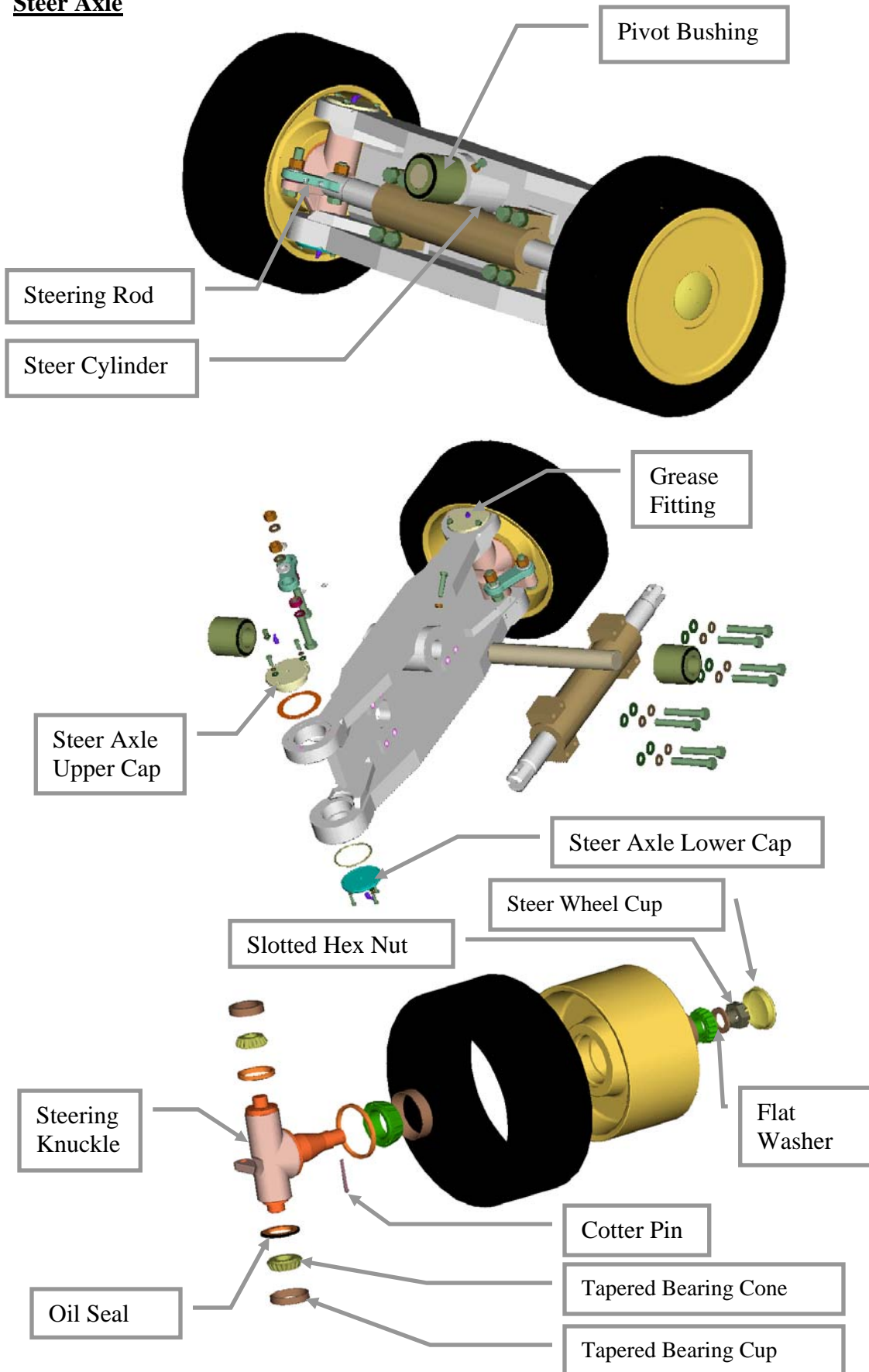
Long-life bushings require correct lubrication for maximum performance and bushing life. Although you do not have to replace spider cam bushings on trailer axles as frequently, Meritor recommends that you lubricate the bushings at least four times during the life of your brake lining.

Automatic Slack Adjusters

- "Automatic" doesn't mean maintenance-free. Properly installed and lubricated automatic slack adjusters help to ensure maximum brake system performance.
- Never mix automatic slack adjusters on the same axle. When you replace automatic slack adjusters, always use replacement parts that were originally designed for the brake system to help ensure even brake wear, balanced braking and maximum brake performance.

F-Series Steer Axle

Steer Axle



Removal of Steer Axle

1. Make sure the wheels are not turned allowing for straight travel.
2. Place the truck on Blocks. The truck must be level and 18" min. above the floor to allow the Steer axle to be removed.
3. Clean the fittings on the hydraulic lines to the Steer Axle and remove them. Plug the fitting to prevent leaking and or contamination.
4. Using a floor Jack or the forks of another forklift place the lifting device under the Steer Axle and lift until the weight of the Steer Axle is supported by the lifting device.
5. Remove the four Cap Screws that hold the Pivot Bushings to the Chassis.
6. Slowly Lower the Steer Axle from the Truck.
7. Place the steer Axle on Stands.

Installing the Steer Axle

1. Make Sure the wheels are set for straight travel.
2. Using a floor jack or another forklift, raise the Steer Axle up under the Truck.

3. Install the two caps and the four bolts and washers that retain the Pivot Bushings to the Chassis and torque to.
4. Remove the plugs in the hydraulic hoses clean the fittings to prevent contamination and install the hoses.
5. Before you take the truck off the blocks, start the truck and check for proper operation of the steer cylinder.

Removing the Steer Cylinder

The Steer Axle has to be removed from the truck to remove the Steer Cylinder.

1. Place the Steer Axle on Stands with the cylinder on the Side. If you place the cylinder up the wheels will swing down when the Cylinder is removed. Causing an unnecessary hazard and making it difficult to re-install..
2. Remove the Two Bolts holding the steering rods to the Cylinder. Take care as these bolt retain bearings inside the steering rod.
3. Remove the eight cap screws holding the cylinder to the Steer Axle and remove the cylinder.

F-Series GM 5.7L Tier 2 Engine

STARTING PROCEDURES

FOR ALL INTERNAL COMBUSTION FORKLIFTS & EQUIPMENT

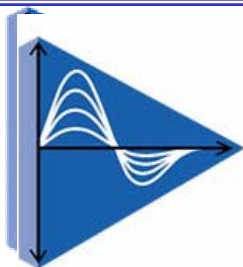
GASOLINE OR LPG ENGINES

1. IF THE LIFT TRUCK USES LPG FUEL, OPEN THE FUEL VALVE ON THE LPG TANK. ***WARNING!!! LPG is very flammable. An odor of LPG fuel can indicate a leak in the fuel system. DO NOT start the engine until the leak is repaired.***
2. MAKE SURE THE PARKING BRAKE IS APPLIED OR PUSH ON THE BRAKE PEDAL.
3. IF EQUIPPED, PUT THE DIRECTION CONTROL LEVER IN THE ***NEUTRAL (N)*** POSITION.
4. TURN THE KEY TO ***START*** POSITION TO ENGAGE THE STARTER. ***WARNING!!! Do not engage the starter for more than 30 seconds at a time. If the engine does not start, turn the key switch to OFF. Wait 60 seconds before engaging the starter again.***
5. IF THE ENGINE DOES NOT START AFTER FOUR ATTEMPTS, GET HELP FROM AUTHORIZED SERVICE PERSONNEL.
6. WHEN THE ENGINE IS RUNNING, CHECK THE GAUGES AND INDICATOR LIGHTS FOR CORRECT OPERATION.

NOTE: CHECK THE INSTRUMENTS PRIOR TO OPERATING THE TRUCK. THIS WILL ALLOW THE COMPUTER AND HYDRAULIC SYSTEM THE TIME NEEDED TO “***READ***” AND ADJUST TO THE OPERATING CONDITIONS WHICH TAKES LESS THAN 10 SECONDS.

THIS ALSO ALLOWS THE LUBRICATING OIL IN THE ENGINE, TRANSMISSION AND HYDRAULIC SYSTEM TO CIRCULATE PREVENTING PREMATURE WEAR TO ANY COMPONENTS IN THESE SYSTEMS.

THIS IS A GOOD OPERATING PROCEDURE FOR ***ANY*** ENGINE DRIVEN EQUIPMENT.

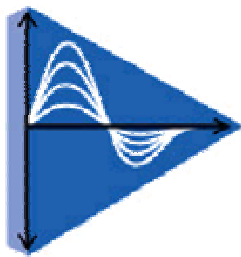


Precision Governors, LLC

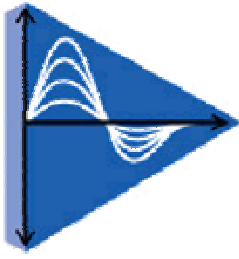
2322 Seventh Avenue, Rockford, IL 61104
phone 815.229.5300 • fax: 815.229.5342
www.precisiongovernors.com
ISO 9001 Certified



User Manual for EFI Fuel Systems



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Contact List

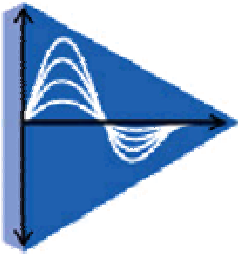
Please direct all questions and inquiries to KEM Equipment at:

KEM Equipment Inc.

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10800 S.W. Hermann Rd
Tualatin, OR 97062
Phone: (503) 692-5012
Fax: (503) 692-1098
Dona@kemequipment.com

Precision Governors LLC

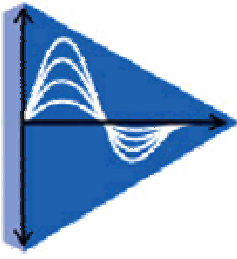
Paul Hanson
Customer Service and Repair
2322 Seventh Avenue
Rockford, IL 61104
Phone: (815) 229-5300
Fax: (815) 229-5342
phanson@precisiongovernors.com



EFI

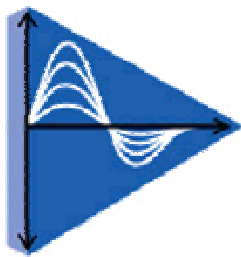
Engine Management System

Overview



EFI Fuel System

- **Integrated product design built around off-the-shelf automotive components.**
- **Certified to meet EPA/CARB 2004 off-road large spark ignition engine emission requirements.**
- **Advanced Speed governing with TPS feedback**
- **Advanced Spark ignition timing for each fuel type**



EFI System Overview

Precision/KEM Certified Engines 2004 Certified Emissions Results

GM Engine	Fuel	Max HP	HC+NOx certified	CO certified	HC+NOx % to std	CO % to std
1.6L	Gas/LPG	45	1.96	12.35	65%	33%
3.0L	Gas/LPG	68	0.9	4.4	30%	12%
4.3L	Gas/LPG	103	0.9	13.9	30%	37%
5.7L	Gas/LPG	128	0.5	7.7	17%	21%



GM 1.6L



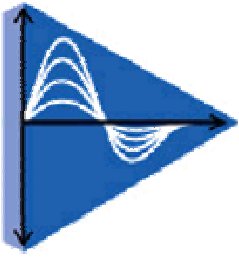
GM 4.3L



GM 3.0L



GM 5.7L



ECM System Components

- Governed Throttle body
- Fueling components



Gasoline

LP components



- ECM

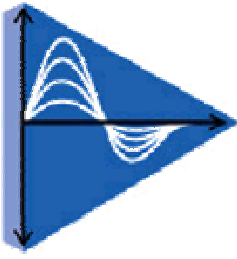


- Engine sensors



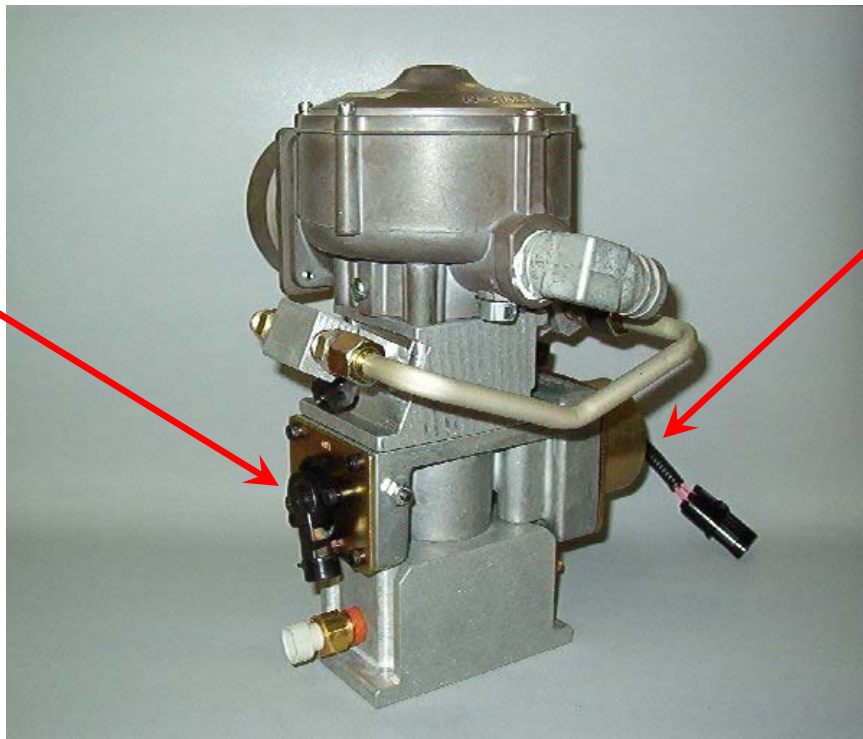
- Harness





Governed Throttle Body Dual - Fuel GM Engine

**Throttle
Position
Sensor**



*Quick
response
actuator*

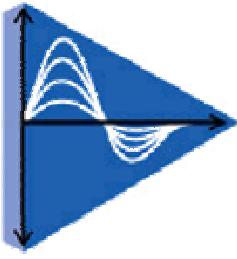
Certified On the Following GM Engines

1.6 L

3.0 L

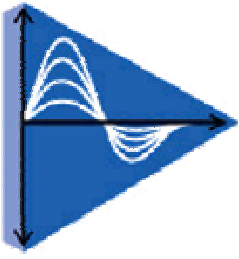
4.3 L

5.7 L



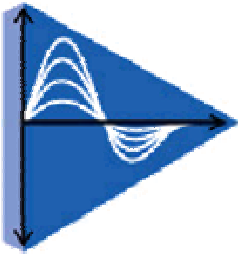
Speed Governing Modes

- **4 Discrete speeds**
- **Ramp – up / ramp – down speed select**
- **Drive by wire**
 - **Potentiometer**
 - **Foot pedal**
- **Custom plus**

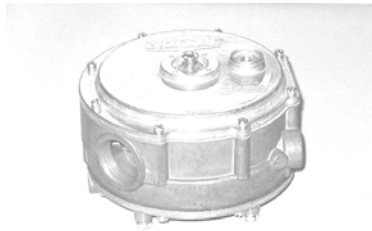


Gasoline Fuel System

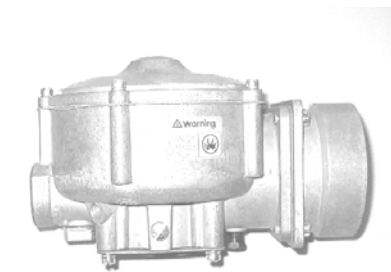
- **Siemens fuel injectors**
- **8 grams/second @ 42 psi.**
- **Throttle body fuel injection**



Gaseous Fuel System for LP, NG, & CNG

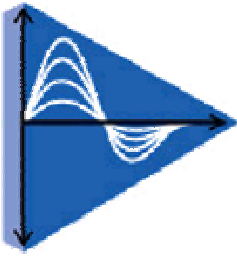


- **Use conventional gaseous fuel components for LPG and CNG**

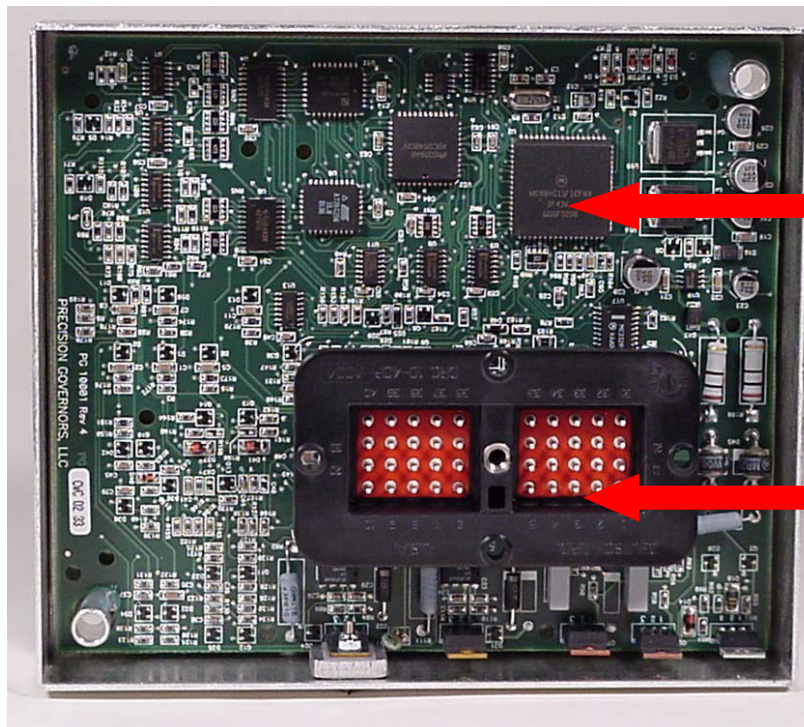


- **Lockoff valve, Vaporizer, Vacuum Valve, LP mixer**
- **Proven field reliability**
- **Avoids known problems with LP injectors**





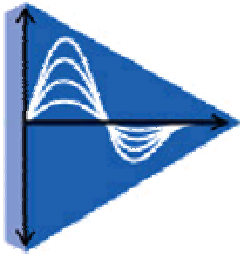
Electronic Control Module (ECM)



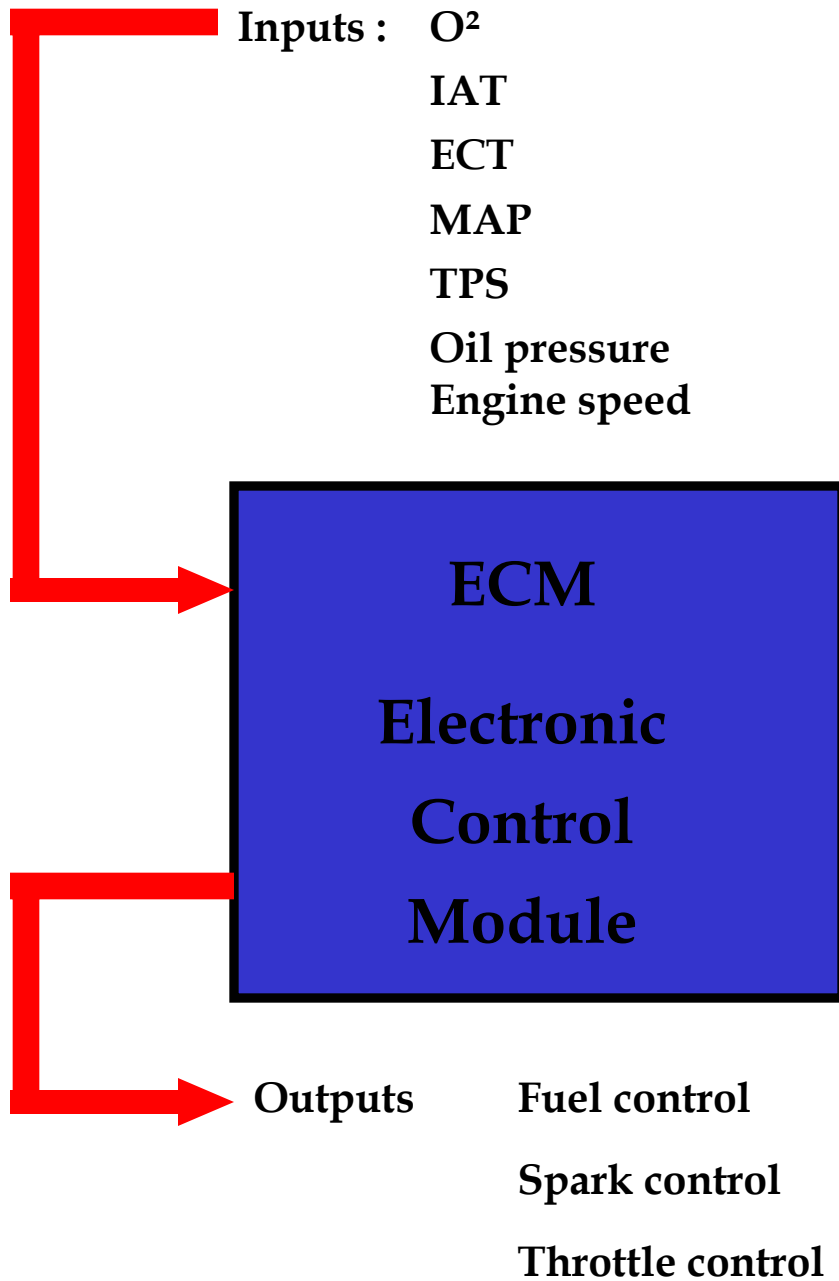
Microprocessor

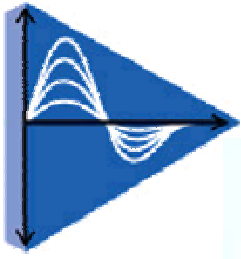
40-pin Deutsch
sealed connector

- Motorola Microprocessor controlled
- Environmental : SAE J1211-4.2
- Vibration: Mil-STD-202G at 9.2G
- Temperature Rating -40 deg to 185 deg F,
- EMI SAE J1113/21 60 VOLTS/METER
- Integral Heat sink Aluminum enclosure.
- Additional I/O capability for accessories.
- Remotely vertically mounted away from the engine.



Engine Control System





Engine Sensors

O₂ sensor

Exhaust gas emission control

MAP sensor

Engine vacuum

IAT sensor

Inlet air temperature

ECT sensor

Engine coolant temperature

Magnetic speed

Speed sensing

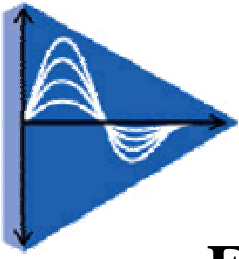
TPS

Throttle position sensor

Oil pressure sensor

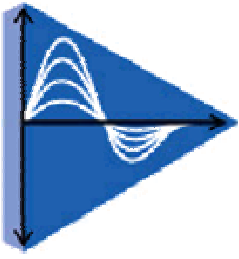
Low oil pressure shutdown





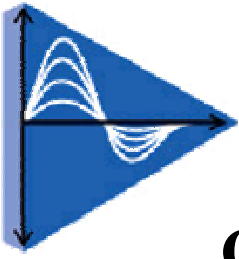
Engine Safety Shutdown Features

- **High engine coolant temperature**
 - **Programmable**
 - **Currently set at 230°F**
 - **Can be customized**
- **Low oil pressure shutdown**
- **Shuts engine down by shutting off fuel**

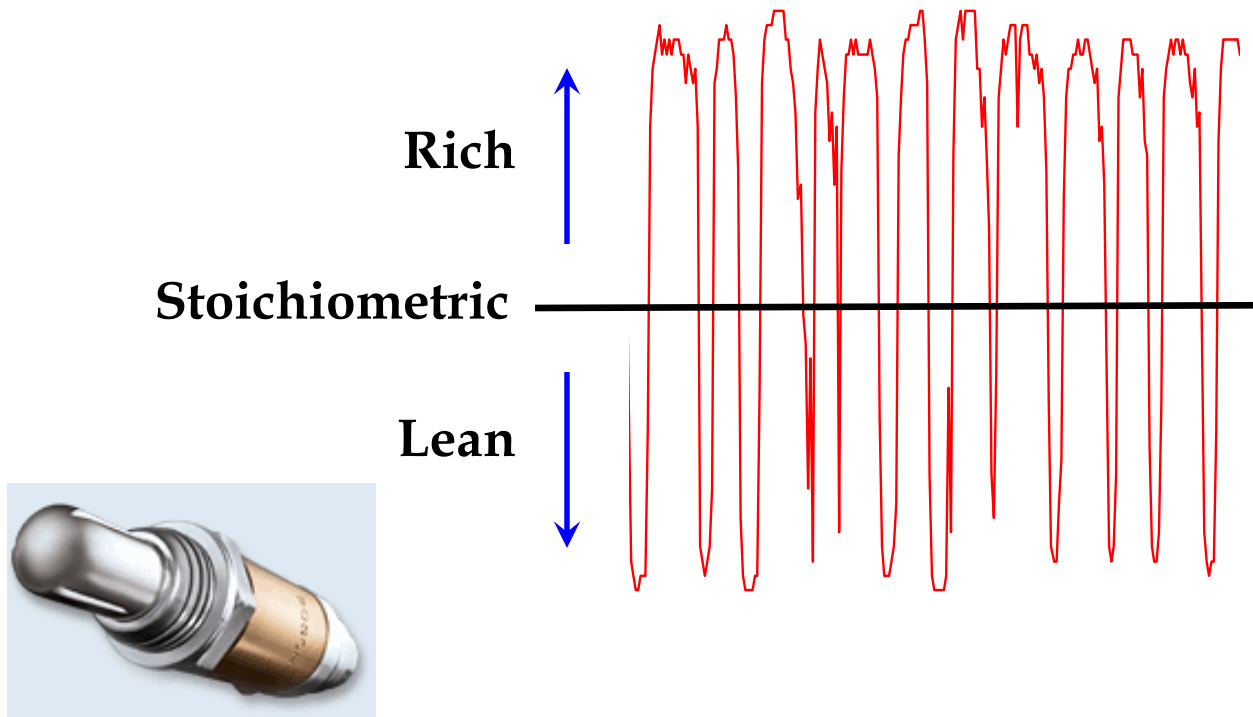


Cold Start Performance

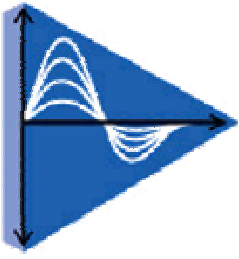
- Gasoline engines to -20°F (-30°C)
- LPG engines to 0°F (-17°C)



Closed-Loop Emissions Control

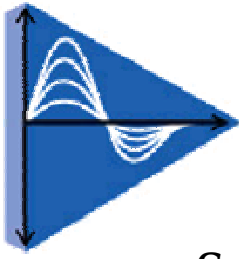


- **O₂ sensor indicates rich or lean condition**
- **Air-fuel ratio is controlled to optimize catalyst efficiency**
- **Automatic altitude compensation**



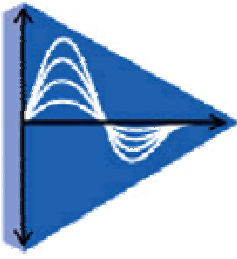
Diagnostics

- **Malfunction Indicator light (MIL) diagnostics**
- **MIL diagnostics for critical engine components including: throttle body actuator, gas injector, ECM, & all engine sensors**
- **Easy for field troubleshooting**
- **Uses simple error blink codes.**



Summary of Diagnostic Error Codes

<u>Error Codes</u>	<u>Error Description</u>
12	Diagnostic mode indicator
13	Oxygen sensor error
14	Engine coolant temp – high
15	Engine coolant temp – low
21	Throttle position sensor error
22	Throttle body actuator not responding
23	Inlet air temp sensor – low
24	Inlet air temp sensor – high
25	Electronic ignition control error
31	Drive by wire error
32	System voltage low
41	Manifold absolute pressure sensor error
42	Gasoline injector fault
51	EEPROM fault
52	Analog to digital converter fault
61	LP solenoid relay fault
62	Fuel pump relay fault
63	Dual fuel relay fault
64	Ignition power relay output error



MIL Diagnostic Description

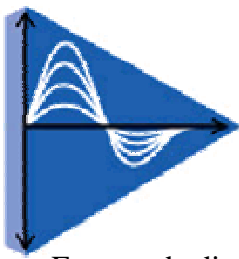
The machine's diagnostic LED is mounted in a place visible to the operator. The LED is a 2-wire device and it must be wired according to the diagram. If it is not connected correctly, the LED will not light.

Many machine or fueling problems are wiring or wiring related.

First, perform a visual inspection of the system. Unplugged, cut, or damaged connections and wires should be corrected or replaced before attempting further diagnosis.

The diagnostic LED provides a method to identify a systemic malfunction. The code format will consist of a number of blinks, a pause, a second number of blinks, then a longer pause. The first set of blinks is the 10's digit of the error code. The second set of blinks is the one's digit of the error code. After the longer pause, the next error code will be sent. At the conclusion of the error codes, a code 12 will be sent then the sequence will repeat itself.

The error codes are repeated sequentially until the malfunction is fixed or the engine has begun running. The first error code that is blinked is code 12, then all active error codes in ascending order, then it is finally concluded with a code 12 again.



Error code diagnostics below:

Code 12:

Code 12 is a special code signifying the beginning or end of the error codes.

Code 13:

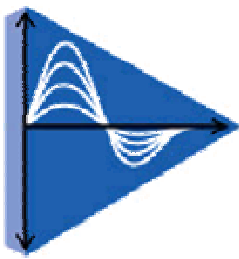
Code 13 indicates the oxygen sensor has not warmed up or has stuck rich, lean, or neutral for a period of time. Other fuel system issues can cause this; for example, incorrect fuel pressure or a leak in the MAP sensor hose.

To verify the O2 sensor wiring:

1. Verify fuses are intact.
2. Disconnect O2 sensor connector, and turn ignition power on.
3. Measure voltage across harness O2 connector pins A (-) and B (+). This should read near 0.45 volts.
4. If not. Turn off power
5. Disconnect ECM
6. Check connections shown in Table 5.

Meter mode	From	To	Desired Result	If defective
Ohms	ECM 10	Harness O2 A	$< 1 \Omega$	wire is open
Ohms	ECM 10	Harness O2 B	Open	wire is shorted
Ohms	ECM 20	Harness O2 A	$< 1 \Omega$	This wire is open
Ohms	ECM 20	Harness O2 B	Open	wire is shorted

Table 5 : Harness O2 sensor check



. Turn on ignition power.

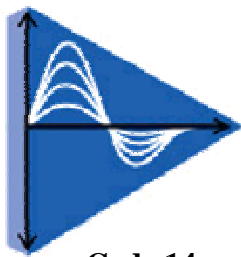
.1. Measure the voltage across harness O2 sensor connector pins C(+) and D (-).

his This should read near the battery voltage: if not proceed to the step 7.1.1.

Meter mode	From	To	Desired Result	If defective
.1.1. Perform the first measurements in Table 6.				
Voltage	Ground	Harness O2 C	Battery voltage (10-14)	O2 C wire is open
Voltage	Battery +	Harness O2 C	< 1 volt	O2 C wire is open
Voltage	Ground	Harness O2 D	< 1 volt	O2 D wire is open
Voltage	Battery +	Harness O2 D	Battery voltage (10-14)	O2 D wire is open

Table 6 : Harness O2 heater check

7.2. If battery voltage is present from step 7.1, measure resistance between the 2 white wires on the O2 sensor. They should be between 1.5 and 3.52 ohms at room temperature. If the heater is open or shorted, replace the sensor. A warm sensor will read higher resistance than a cold sensor. If no wires are open or shorted, verify the rest of the fueling system is operating properly. If everything else checks out, replace the oxygen sensor.



Code 14: The engine coolant reads too high. It is possible to receive this code if the engine has severely overheated (above 280 ° F).

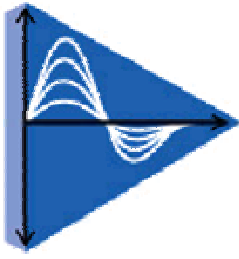
Code 15: The engine coolant reads too low. This may occur if the temperature is below -30° F or if the CTS sensor is unplugged.

To verify the coolant temp wiring:

1. Disconnect the coolant temp sensor and measure the resistance of the coolant temperature sensor. This will vary depending on the sensor's temperature. The resistance should be within 5% of that listed in Table 7. If the sensor differs, replace the sensor.

Table 7: CTS / IAT resistance

Degrees F	CTS Resistance (Ω)	IAT Resistance (Ω)
-22	52594	51791
5	21371	21044
32	9399	12073
68	3511	3457
77	2795	2752
86	2240	2205
95	1806	1778
104	1465	1443
140	671	660
167	395	398
176	334	329
194	242	238
203	207	204
212	178	175
248	100.9	99



Turn ignition power ON.

.1. Measure the voltage between CTS sensor pin A (Wh / BK) and ground. This should read near 5 volts. If it does not proceed to step 2.1.1

.1.1. Turn off ignition power and disconnect the ECM .

.1.2. Measure resistance from ECM pin 9 to CTS pin A. It should read less than 1 Ω . If it does not repair the wire.

.1.3. Measure resistance from ECM connector pin 10 to CTS sensor pin B (Bk/Yl). It should read less than 1 Ω . If it does not repair the wire.

.2. If no sensor or wiring problems are found, replace the ECM.

ode 21:

he TPS sensor is reading incorrectly. Make sure the TPS is plugged in.

o verify the TPS sensor and wiring:

. Disconnect the TPS sensor from the harness.

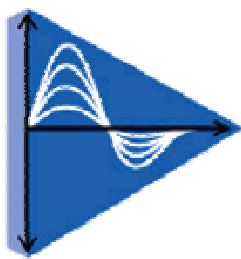
.1. Measure the TPS resistance between TPS pins A and B. This should read 2.5-7.5k Ω . If it is outside this range replace the sensor.

.2. Measure resistance from pin A to pin C while slowly, manually move the throttle plate. The resistance should increase smoothly without dips or spikes. If it is not smooth replace the sensor.

. Turn ignition power ON. Measure voltage from harness TPS connector pins A (-) and B (+). This should measure 4.75 – 5.25 volts. If not proceed to step 2.1.

.1. Perform the following measurements:

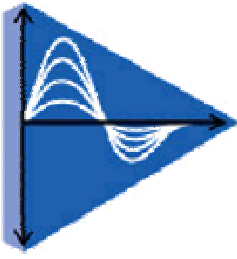
.2. Turn ignition power OFF. Disconnect the ECM from the wiring harness. Disconnect the MAP sensor and drive-by-wire pot (if it is used and easily to disconnect). Perform the



Meter mode	From	To	Desired Result	If defective
Ohms	ECM Harness 10	TPS A	$< 1 \Omega$	Ground wire is open
Ohms	ECM Harness 40	TPS B	$< 1 \Omega$	5 volt wire is open.
Ohms	ECM Harness 8	TPS C	$< 1 \Omega$	TPS signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open, or $< 1000 \Omega$ if DBW pot .	5 volt wire shorted to ground
Ohms	ECM Harness 10	ECM Harness 8	Open	TPS signal shorted to ground
	ECM Harness 40	ECM Harness 8	Open	TPS signal shorted to +5 volts.

Table 8: TPS wiring troubleshooting

If all other TPS tests check out, reconnect all sensors. Measure the voltage from TPS pin C to ground while manually opening the throttle plate. The voltage should read > 0.5 volts at closed throttle and < 4.5 volts at WOT and move smoothly between closed and open throttle. If the voltage has “dead spots” or spikes, replace the TPS sensor. If the voltage is within the range and moves smoothly, replace the ECM.

**Code 22:**

The Throttle body actuator is not responding, the fault is either caused by a short circuit or the actuator is unplugged.

Code 23:

The Inlet Air temperature reads too low. This may occur if the temperature is below -40° F or if the IAT sensor is unplugged.

Code 24:

The engine coolant reads too high. While unlikely, if this sensor is above 270 ° F this code will be sent.

o Verify the Inlet Air Temperature sensor wiring:

- . Disconnect the IAT sensor and measure its resistance. This will vary depending on the sensor's temperature. The resistance should be within

5% of that listed in Table 7. If the sensor differs, replace the sensor.

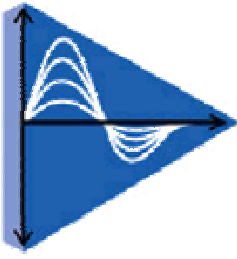
- . Turn ignition power ON and disconnect the IAT sensor.

- .1. Measure the voltage between IAT harness sensor pin A (purple) and ground. This should read near 5 volts. If it does not proceed to step.

- .1.1. Turn off ignition power and disconnect the ECM .

- .1.2. Measure resistance from ECM pin 19 to IAT harness pin A. It should

read less than 1 Ω. If it does not repair the wire.



ode 31:

Drive by wire fault: the drive by wire voltage is too low or too high.

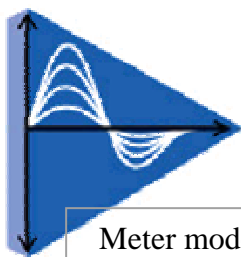
This code can be set in some systems if the drive by wire pot is set to one extreme or the other. First, set the pot at least 1/8 of a turn from either end. If the error code is gone, there is no problem. If the machine does not utilize the DBW device, this error can be ignored.

As the DBW device is OEM specific, the resistance values can vary depending on what device is used. Recommended potentiometer ranges are 1k Ω to 10k Ω .

To verify the DBW sensor and wiring:

- . Turn ignition power ON. Measure voltage from harness DBW ground wire (Bk/Yl) and 5 volts (Rd/Bu). This should measure 4.75 – 5.25 volts. If not proceed to step 1.1.
- .1. Turn off the ignition power, disconnect the DBW sensor from the harness, if possible, and disconnect the ECM.
- .2. Measure the resistance between DBW control ground (Harness wire Bk/Yl) and supply (Harness wire RD/BU). This should read close to the pots resistance (in the range of 1k Ω to 10k Ω) however if it reads open or shorted the unit is defective.
- .3. Measure the resistance from the pots ground lead to the output lead (harness GN/YL). The resistance should start low when the pot is turned to the low side and increase smoothly as the pot is turned to the high side. If the resistance does not smoothly increment or has discontinuities, replace the DBW device.

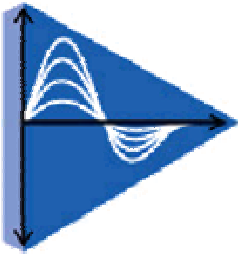
Turn ignition power OFF. Disconnect the ECM from the wiring harness. Disconnect the MAP sensor and TPS. Perform the measurements in Table 9.



Meter mode	From	To	Desired Result	If defective
Ohms	ECM Harness 10	DBW GND (BK/YL)	< 1 Ω	Ground wire is open
Ohms	ECM Harness 40	DBW +5 (RD/BU)	< 1 Ω	5 volt wire is open.
Ohms	ECM Harness 8	DBW output (GN/YL)	< 1 Ω	DBW signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open, or < 1000 Ω if DBW pot is connected	5 volt wire shorted to ground
Ohms	ECM Harness 10	ECM Harness 18	Open	TPS signal shorted to ground
	ECM Harness 40	ECM Harness 18	Open	TPS signal shorted to +5 volts.

Table 9: DBW wiring troubleshooting

1.4 If all other DBW tests check out, reconnect all sensors. Measure the voltage from DBW output to ground while manually opening the throttle plate. The voltage should move smoothly between low speed and high speed. If the voltage has “dead spots” or spikes, replace the DBW device. If the voltage is within the range and moves smooth, replace the ECM.



ode 32: System voltage too low.

This indicates the ECM is receiving a low battery voltage measurement. Verify the battery voltage measures above 10 volts while the engine is running.

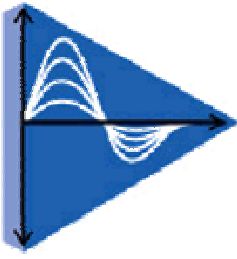
- . Measure the system (battery voltage) during normal operation. If it is below 12.5 volts the charging system should be diagnosed. Normal running battery voltage should read approximately 13 – 14.5 volts. If the battery voltage is low, the charging system or machine wiring should be diagnosed.

- . Turn ignition power off, then disconnect the ECM. Turn ignition power ON. Measure the voltage between pins ground (25 or 35) and switched power (11) and then the battery voltage. The 2 readings should be within 0.5 volts. If the readings vary considerably, proceed with step 0. Acceptable voltage drops should be less than 0.5 volts unless the machine draws current for other functions. If any wires show considerable voltage drops that wire should be inspected for damage or poor connections.

- .1. Measure the voltage between battery ground (-) and ECM pin 25. This voltage should be near 0.

- .2. Measure the voltage between battery ground (-) and ECM pin 35. This voltage should be near 0.

- .3. With ignition power still ON, measure voltage between ECM pin 11 and battery positive. This should be near 0.

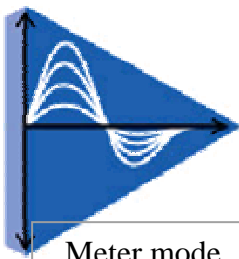


Code 41: MAP sensor system error

The MAP sensor code can be set if: map output wire is grounded, shorted to +5 volts, or if the MAP pressure does not change between key on and engine run time.

Verify:

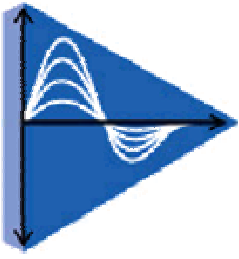
1. MAP sensor is plugged in.
2. Vacuum hose to the MAP sensor is connected properly with no leaks.
3. Disconnect MAP sensor electrical connector. Turn ignition power on.
Measure the voltage from pins A (Bk/Yl) to C (Rd/BU). This should read 4.75-5.25 volts. If it outside of this range proceed with step 3.1
- 3.1. Perform the following measurements:
- 3.2. Turn ignition power OFF. Disconnect the ECM from the wiring harness.
Disconnect the TPS sensor and drive-by-wire pot (if it us used and easily to disconnect). Perform the measurements in Table 10.



Meter mode	From	To	Desired Result	If defective
Ohms	ECM Harness 10	MAP A	< 1 Ω	Ground wire is open
Ohms	ECM Harness 40	MAP C	< 1 Ω	5 volt wire is open.
Ohms	ECM Harness 8	TPS C	< 1 Ω	TPS signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open, or < 1000 Ω if DBW pot is connected	5 volt wire shorted to ground
Ohms	ECM Harness 10	ECM Harness 7	Open	MAP signal shorted to ground
	ECM Harness 40	ECM Harness 7	Open	MAP signal shorted to +5 volts.

Table 10: MAP wiring troubleshooting

4. If all other MAP tests check out, reconnect all sensors and turn ignition power on. Measure the voltage from MAP pin B to ground while manually applying vacuum to the vacuum fitting on the map sensor. The voltage will depend on the vacuum but should read from 0.1 volt under high vacuum to 4.7-5 volts at atmosphere pressure and sea level. If the voltage is within the range, replace the ECM.

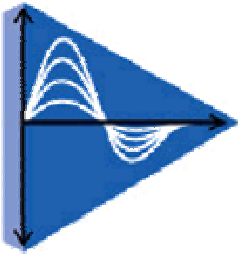


Code 43: Fuel injector error.

The fuel injector circuit is not responding properly. The circuit has an open, short, or lost power from the power relay. If the injector shows a true fault, it is unlikely the engine would run on gasoline. The injector could be turned on all the time and therefore it would squirt gasoline continuously when the ignition relay is active. This would tend to flood the engine; however, it may run depending on loading and other conditions.

Verifying Fuel injector fault:

- . Verify the ignition relay is operating properly as described in Code 64. The ignition relay provides power to the fuel injector.
- . Disconnect the fuel injector. Connect a volt meter between ground and injector pin A (Rd / Bk). Switch the ignition from off to on and verify the injector pin has battery voltage applied for the 2 second fuel pump prime time period. If this voltage is not present, continue with step. Reference 2.1.
 - .1. Connect voltmeter between ground and pin 87 of the ignition coil and fuel injector relay. Switch the ignition power off to on. Verify 12 volts is present at in 87 during the 2 second initial prime period. If the voltage is present, proceed with step 2.1.1.
 - .1.1. Recheck the ignition power relay as described in Code 64.
 - .2. Turn off ignition power. Measure resistance from relay pin 87 (Rd / Bk, of the ignition coil and fuel injector relay) and injector pin A (Rd / Bk). This should measure $< 1\Omega$. If the measurement is greater repair the wire.
- . Turn off the ignition power. Measure the resistance of the fuel injector. The resistance of a room temperature injector should read 1-2 Ω . Replace the injector if the resistance is considerably outside this range.
- . Disconnect the ECM from the harness. Measure the resistance from ECM harness pin 4 and injector connector pin B. This should read $< 1\Omega$. If it is greater repair the wire.
- . Measure the resistance from ECM harness pin 25 and injector connector pin B. This should read open. If it shows continuity repair a short to ground.



ode 53: Low oil pressure fault:

The engine has exhibited low oil pressure during run time.

The oil pressure wire has been shorted to ground or power (this input depends on how the ECM and machine is configured). The low pressure shutdown system is intended for use with a low pressure “switch” not an analog pressure sensor. If the system uses a pressure sensor it must be replaced with a switch. Some machines may also use the shutdown wire for other shutdowns such as over temperature, overload, or others as the OEM deems appropriate. Ensure these are not causing the problem.

o verify the oil pressure fault wire:

. Disconnect oil pressure wire. Turn ignition power on. Measure the voltage present on the oil pressure wire (PU/Wh). If the voltage is less than battery voltage proceed to step. Reference 1.1.

.1. Verify the engine contains the proper level of oil.

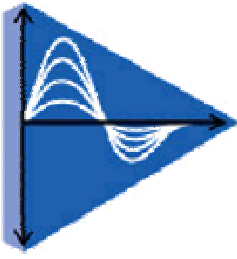
.2. Turn ignition power off and disconnect ECM from the harness. Measure resistance from ECM pin 14 to the oil pressure shutdown terminal. This should be $< 1\Omega$. If the resistance is higher repair the wire.

.3. Measure the resistance from ECM pin 14 (oil pressure) to ECM pin 25 (ground). If this is not open the wire contains a short – repair the wire.

.4. Measure the resistance from ECM pin 14 (oil pressure) to ECM pin 11 (power). If this is not open the wire contains a short – repair the wire.

.5. To test functionality of the wire, connect the ECM and start the engine. For engines with a standard “short to ground on fault” sensor, short the wire to ground. The engine should shutdown within 15 seconds. If it fails to shutdown, perform step 1.6.

.6. For engines with a “connect to power on fault” sensor, short the shutdown wire to switched power. The engine should shutdown within 15 seconds. If it fails to shutdown, perform step 1.5



Code 61: LP power solenoid fault:

Verify connections .

Code 62: Fuel Pump Relay fault:

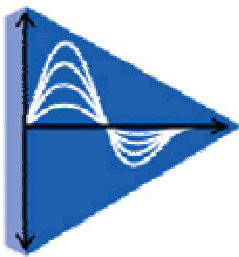
Verify connections .

Code 63: Dual fuel relay fault

Verify connections .

Code 64: Ignition power relay output error

Verify connections .



Basic Trouble Shooting Guide

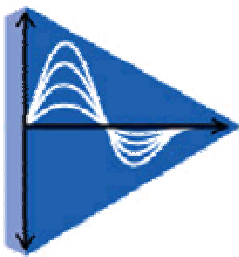
The following is a guide to the most common engine performance complaints.
The guide is used to diagnose problems that are due to worn out components and/or bad adjustments in the Fueling system.

Condition: Engine will not start (Gasoline)

Verify each item below:

Remedy for each item

Fuel Tank Level	Add Fuel
Check fuel pump. Cycle ignition switch on/off, fuel pump should run for 2 seconds.	Check wiring and fuse/relay
Use a pressure gage connected to fuel port. Verify the fuel pressure should read between 40-45 psi.	Check and or Replace fuel filter and/or And/or Fuel Pressure regulator And/or fuel pump
Fuel injector is spraying.	Check fuel injection wiring
Fuel injector is not leaking.	Replace injector o-rings or injector
Spark plugs are not fouled or wet.	Disconnect the fuel injector connectors for 15 seconds while cranking to un-flood the engine.

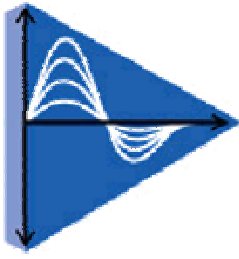


Condition: Engine runs too Rich with Gasoline

Verify each item below

Remedy for each item below

Verify vacuum leaks to the MAP sensor	Replace hose
Restricted fuel return line	Replace fuel line
LPG shut-off valve does not close	Shut-off LPG tank valve, replace/clean LPG shut-off valve
Check fuel pressure should be 40-45 psi (gasoline) at the fuel port.	Replace fuel pressure regulator
Check for bad MAP sensor	Replace with new MAP sensor
Check for a bad IAT, ECT sensor	Replace with new sensor
Check for exhaust air leaks before the O² sensor	Repair air leaks in the exhaust system
Check to see if there is excessive smoke while running.	Check and replace fouled spark plugs

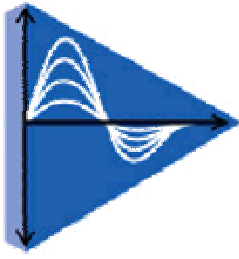


Condition: Engine runs lean or misfires on Gasoline.

Verify each item below

Remedy for each item below

Visually inspect fuel filter for restriction	Replace fuel filter
Verify the fuel pressure is 40-45 psi use gage readings from the fuel port.	Replace fuel pressure regulator
Check for clogged fuel injectors	Clean/Replace fuel injectors
Visually inspect Map sensor for hose breaks	Replace hose
Check for Bad map sensor	Replace with new MAP sensor
Check for Bad IAT sensor	Replace with new IAT sensor
Check for intake manifold air leaks	Repair all air leaks in the intake system

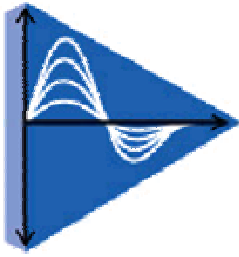


Condition: Engine runs lean or misfires on LPG.

Verify Each item below

Remedy for each item below

LPG tank level	Re-fill Tank
LPG fuel filter is not contaminated and use air pressure to verify restriction.	Replace LPG filter
Clogged fuel lines	Clean fuel lines
LPG pressure regulator/vaporizer is not frozen and /or icing	Check for air leaks ,purge air from coolant hoses. add coolant
Visually inspect Vacuum hose for breaks	Repair
Verify Timing with timing light	Adjust distributor timing
Verify the air filter for the vaporizer is not clogged	Replace air filter
Vaporizer primer button becomes hard to depress when the fuel is present	Replace / Clean LPG fuel lock-off

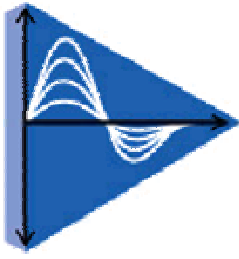


Condition: Engine runs too Rich with LPG

Verify each item below

Remedy for each item below

Verify that there is no air leaks into the vacuum port on the LPG mixer	Replace /repair hose
Check for Clogged Air Filter	Repair/Replace
Check for exhaust air leaks before the O2 sensor	Repair air leaks in the exhaust system
Verify the O2 sensor is working properly	See error code 13
Verify idle air screw is adjusted at idle Fuel trim valve will have a 50% duty cycle	Turn ccw the adjustment screw to lean out the air/fuel mixture
Faulty LPG vaporizer	Replace if LPG vapor pressure is not greater than Atm. Pressure – 2” W.C

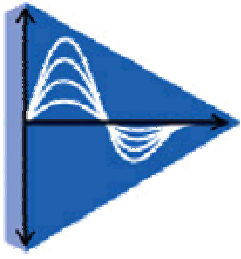


Condition: Engine will not start LPG

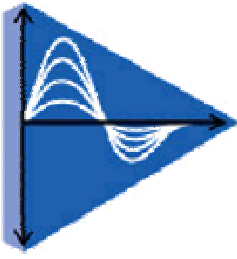
Verify each item below:

Remedy for each item

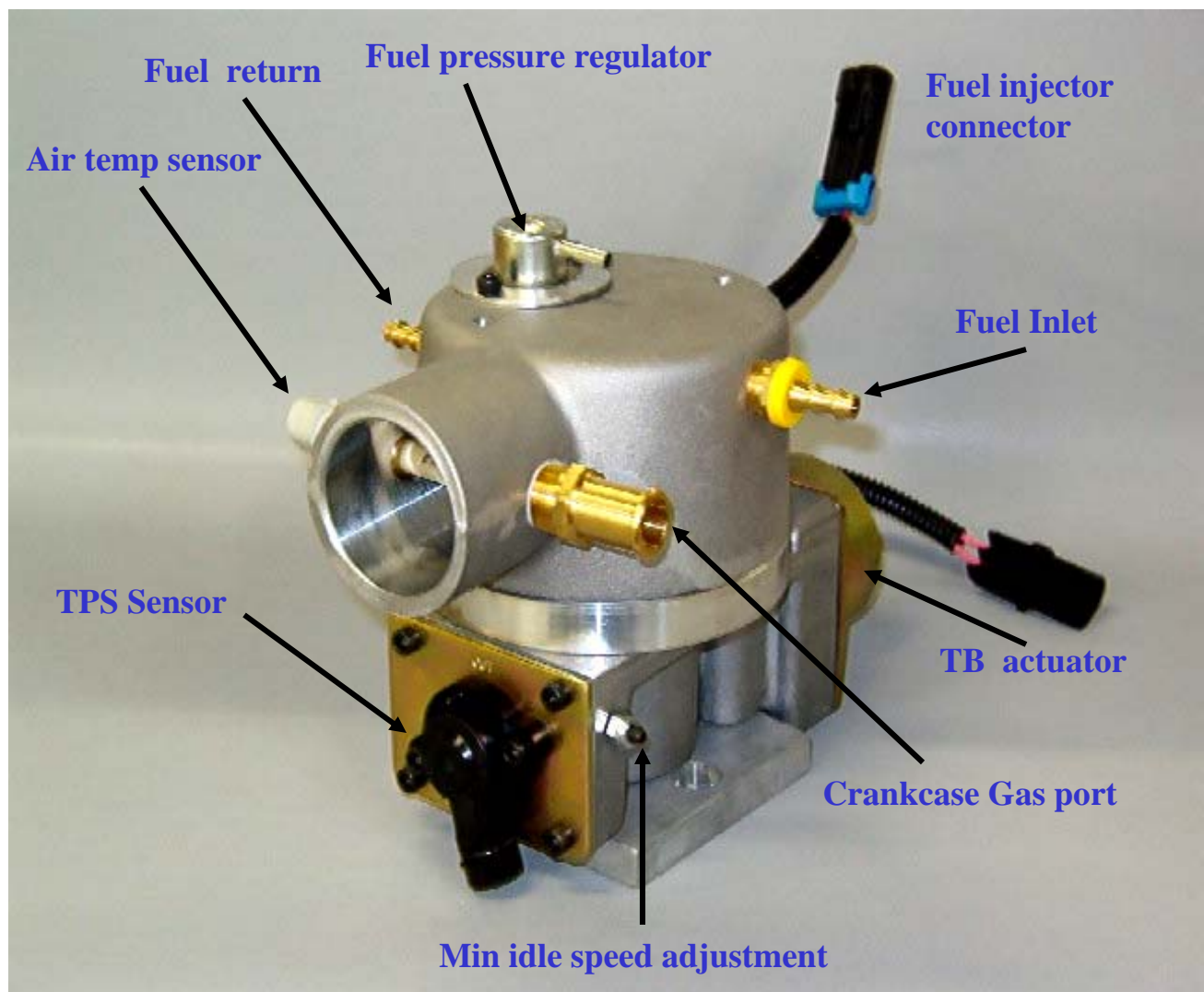
Fuel Tank Level	Add Fuel
Check fuel shut-off valve. Cycle ignition switch on/off, fuel shut off valve should click off after 2 seconds.	Check for obstruction from fuel line Check wiring and fuse/relay
Clogged fuel filter	Close liquid fuel valve Repair/replace fuel filter Open liquid fuel valve, check for leaks
fuel trim vacuum valve is stuck open	Clean valve . Check wiring
Clogged small air filter on top of the vaporizer.	Clean/Replace air filter and orifice jet
Carburetor malfunction	Check diaphragm for holes and damage Repair/Replace

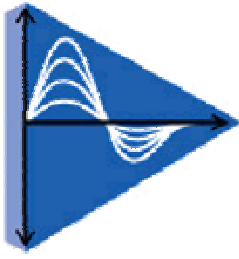


Assembly Detail

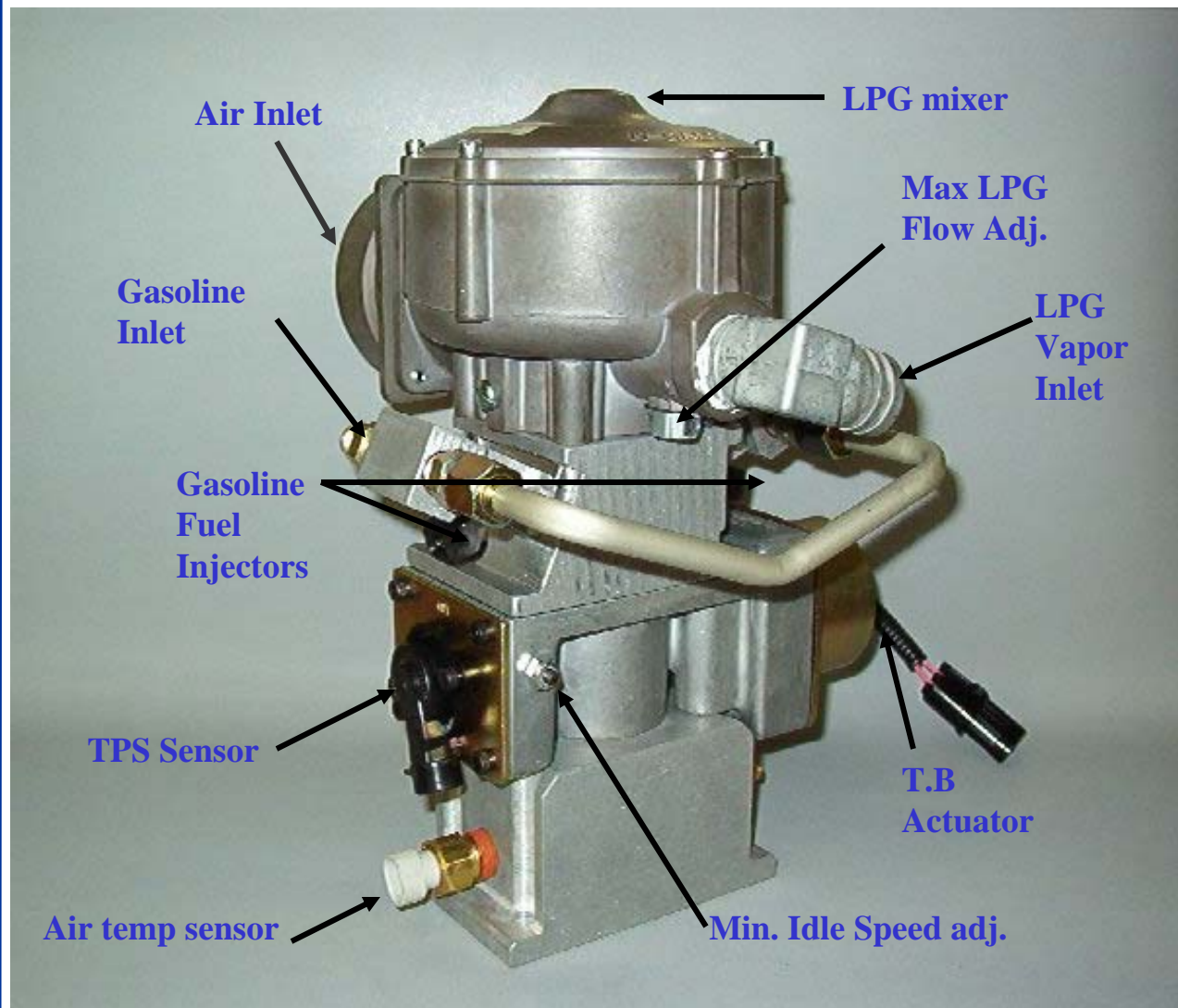


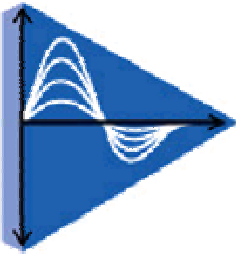
Gasoline Only Fuel Injection Detail Assembly 3.0L Engine typical





Dual Fuel System Detail Assembly 4.3L and 5.7L typical





LPG Gaseous Fuel System Assembly

4.3L and 5.7L engine typical



Coolant Hoses

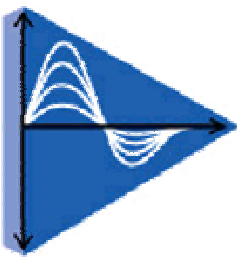
LPG Vaporizer Regulator

vacuum solenoid valve

engine vacuum pressure line

Propane vapor ports

Atmospheric pressure port

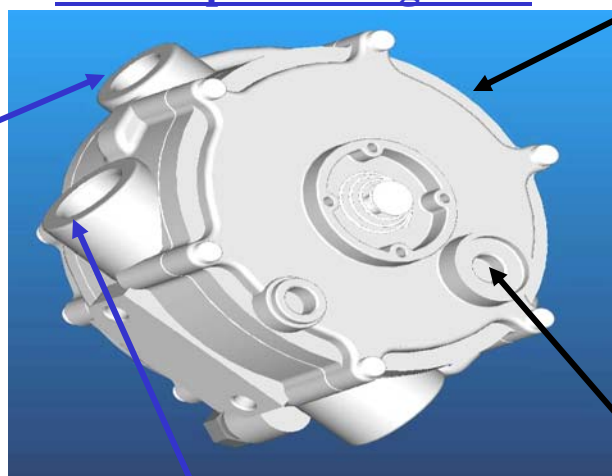


LPG Gaseous Fuel System Assembly

1.6L Engine typical

LPG Vaporizer Regulator

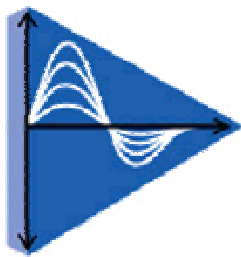
Coolant Inlet /
Outlet
Ports



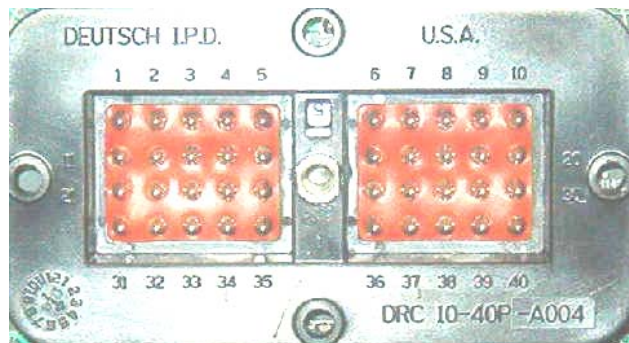
LPG inlet Port

Propane Vapor
Outlet Port

Vacuum
Reference Port



ECM Connector



Deutsch 40-Pin Connector Layout for EFI Harness

Deutsch Part Number - DRC16-40S Quantity - 1

Pin Part Number - 0462-201-16141 Quantity - 26

Functional layout

	1	2	3	4	5	6	7	8	9	10	
1	Ignition Coil B	Ignition Coil A	vacuum valve	Injector - 1	Fuel Sel.	Gov. Sel. 1	MAP - B	TPS - C	ECT - A	Analog GND	10
11	Switched Power	Battery	Tach out	Oil Pressure	Test	Gov. Sel. 2	CPS - A	DBW	IAT - A	hego-	20
21	Power-relay	N/C	MIL	Fuel Relay	Power GND	Emergency-kill	CAM	Analog	knock	transmit	30
31	Actuator -pwm E	LP Shutoff	Actuator - A	Aux-out	Power GND	Dwell-out	Spark-bypass	Flash - 3	receive	5V Ref.	40
	31	32	33	34	35	36	37	38	39	40	

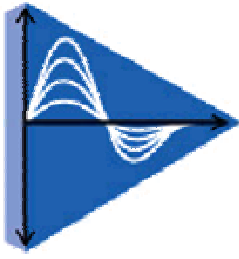
N/C = No Connection

Color Layout

	1	2	3	4	5	6	7	8	9	10	
1	NC	NC	PR/YL	GR/RD	YL/RED	PINK	TAN	YL	WH/BK	BK/YL	10
11	OR	RD/YL	N/C	PR/WH	N/C	BR/WH	BU/WH	GR/YL	PR	BU/YL	20
21	BK/WH	N/C	GR	BK/BU	BK/RD	N/C	N/C	N/C	N/C	GR	30
31	BU	BU/BK	BN	N/C	BK	TN/BK	GR/WH	WH	OR/BK	RD/BU	40
	31	32	33	34	35	36	37	38	39	40	

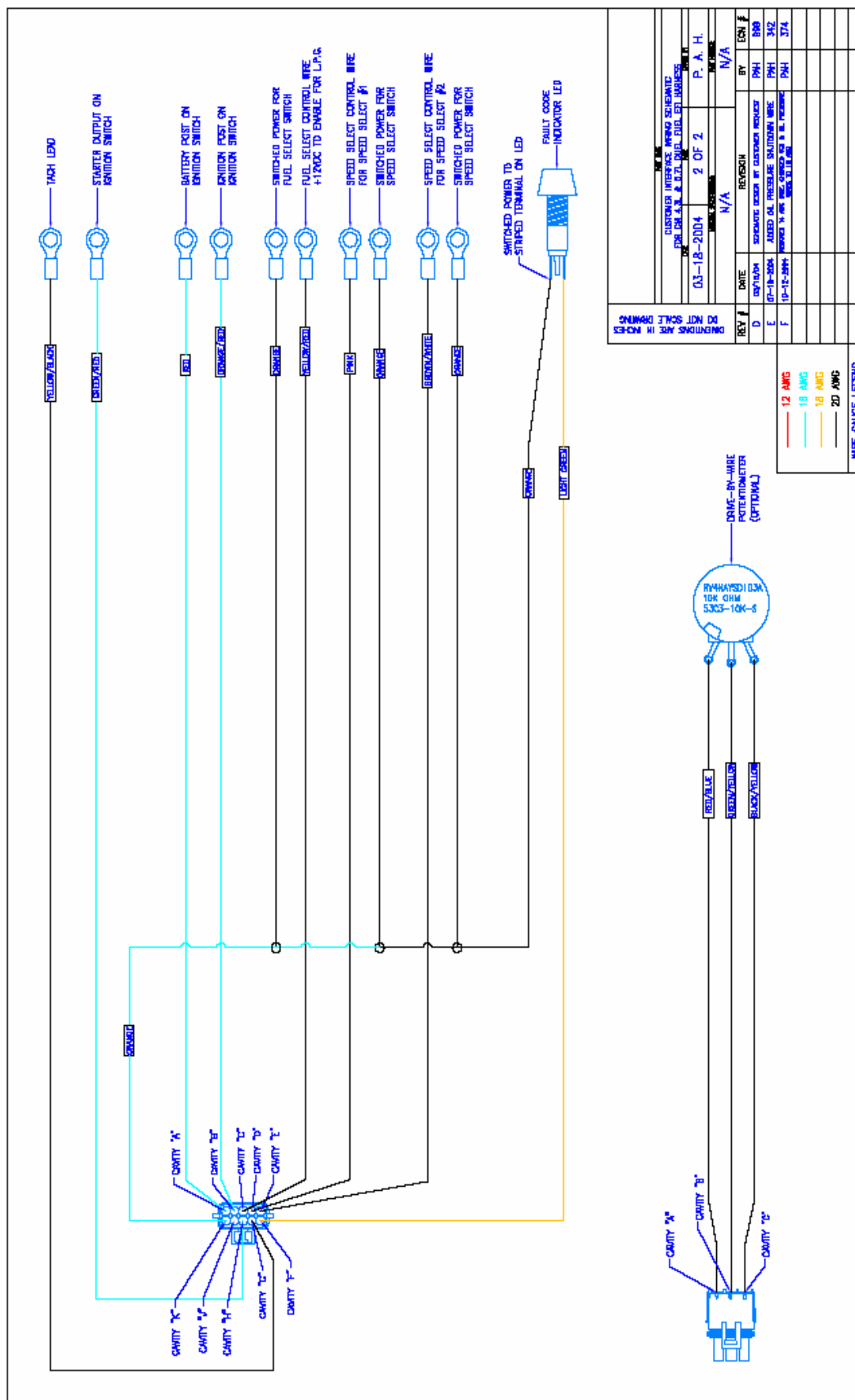
WH = WHITE RD = RED PR= PURPLE BN = BROWN OR = ORANGE GR = GREEN
BK = BLACK PK = PINK TN = TAN GY = GREY YL = YELLOW BU = BLUE

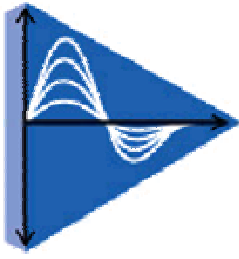
EX: WH / BK & BN = White with Black and Brown stripes



Schematics

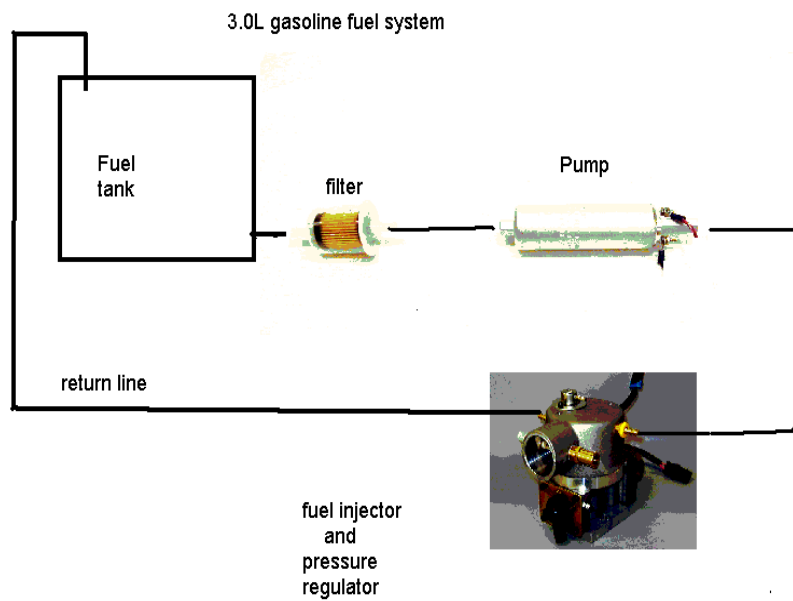


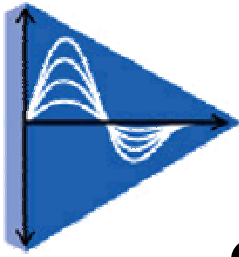




Gasoline Fuel System

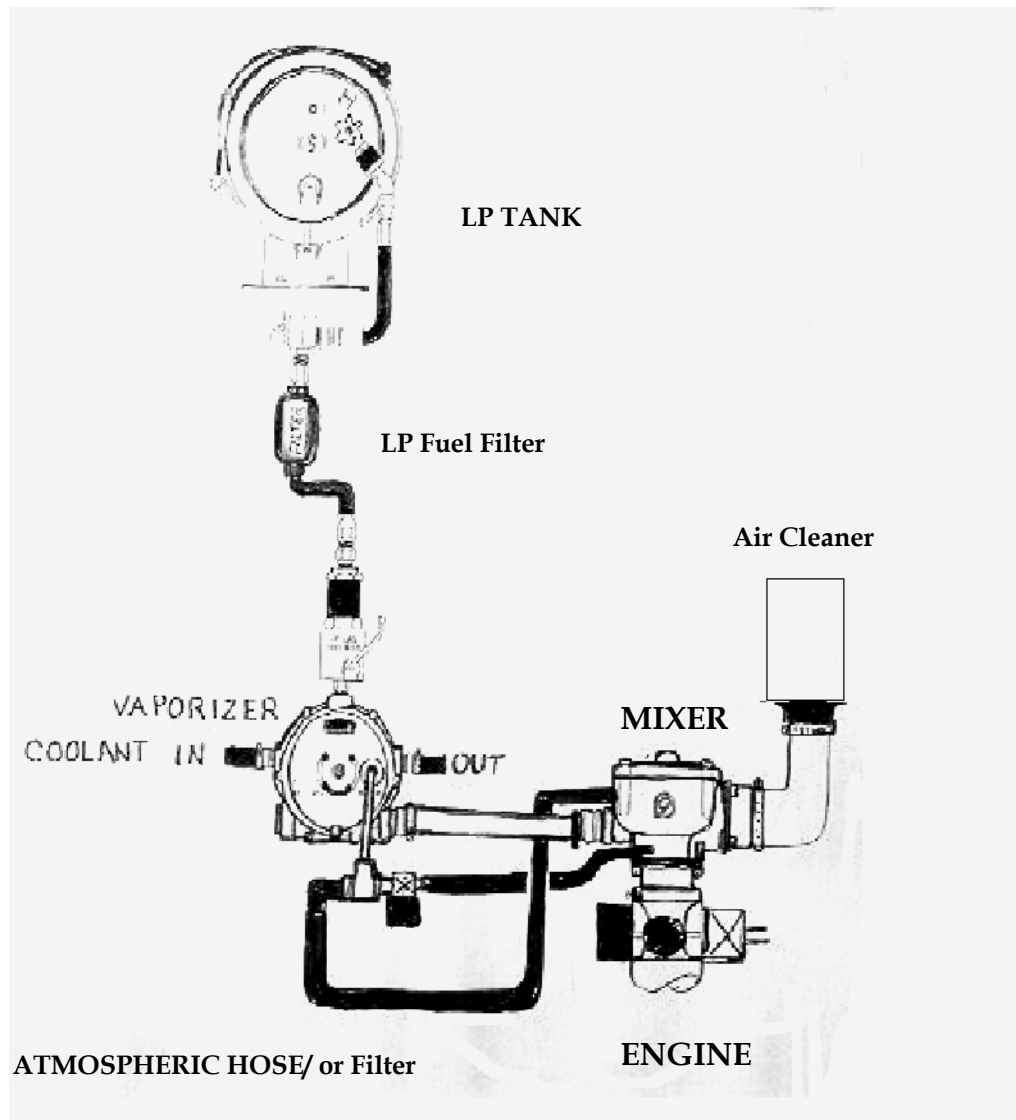
(Plumbing Schematic)

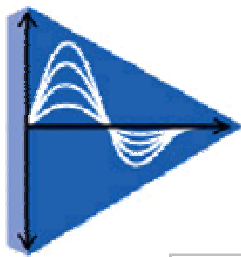




Gaseous Fuel Plumbing

(Schematic)



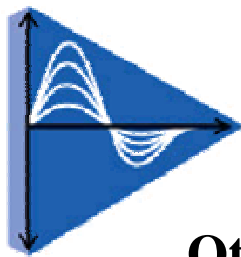


GM 3.0 LPG ONLY

Service Parts

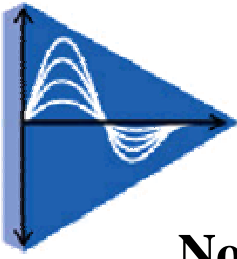
1	94050020	3.0 LP ONLY FUEL KIT
1	HE1-4A	1/8 NPT X 1/4 BARB 90 DEG
2	269HB-12-8	3/4 X 1/2 BARB 90 DEG
2'	H177	3/8 USCG FUEL HOSE
3'	3/4 "HOSE	3/4" LPG HOSE
2	#10	CLAMP
1	110FB-DC	BUSHING, 1/2M X 3/8 FM FACE MT.
1	125HBL-10-8	5/8 X 1/2 HOSE BARB
3	H200	5/8 PCV PUSH ON JIFFY HOSE
4	#08	S.S. HOSE CLAMP
1	PC7688	ACCESSORY BRACKET
2	#12	S.S. HOSE CLAMP
1	10068571	MAP SEN BRACKET
1	N00-5101	1/8 VAC FITTING
1	735-4970	VC GROMMET
2	4-1142	CERTIFICATION LABEL
1	PC7764	MIXER ADPT
1	630-1049	GROMMET
1	PC7686	MAP SEN SUPPORT BRACKET
1	2024-4	1/4 NPT X #6 90
1 *	AFC-A155	LP FILTER
1	LW05	5/16 LOCK WASHER
1	PC7762	PVC LINE RESTRICTOR
1	BHM05C075	5/16 NC X 3/4 BOLT
1	PC7771	CUSTOMER INTERFACE HARNESS
1	230404	OIL SAFETY SWITCH
1	125HLB-4-6	1/4 NPT X 3/8 BARB
1	125HBL-12-8	3/4 X 1/2 BARB
1	122-60	JET
2	BHS0420350	1/4NC X 3 1/2 BOLT
1	2059	BREATHER
1	3046	FILTER
1	211P-2	1/8 NPT PLUG
1	211P-6	3/8 NPT PLUG
1	222P-2-2	1/8F X 1/8 M ADAPTER
1	7388	HOSE

List of Service Items



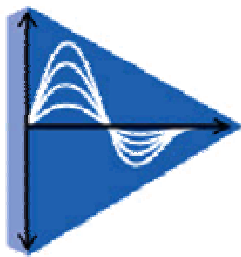
PG # 94050020 Kit

<u>Qty</u>	<u>P/N</u>	<u>Description</u>
1	PG 2560	Map Sensor
1	PG 2561	Oxygen Sensor
1	PG 2562	Coolant Temp Sensor
1	PG 2585	Autotronix Solenoid Valve
2	PG 3143	3/8-16 x 1/2 Socket Hd Cap Screw
2	PG 3206	O-Ring, EFI
13	PG 3322	Hose, Neoprene Vapor, 5/8"
1	PG 3329	Brass, 3/8 Barb x 1/8 NPT-90 Elbow
1	PG 3357	Brass, 3/8 Compression x 1/4 NPT
24	PG 3360	Hose, 3/8" – 24" Minimum
2	PG 3362	Brass, 5/8 Barb x 1/2 NPT 90 Elbow
2	PG 3363	Brass, 5/8 Barb x 3/8 NPT
2	PG 3364	Brass, 5/8 Barb x 3/8 NPT-90 Elbow
2	PG 3435	Brass, 1/8 x 1/8 NPT Male
1	PG 3436	Brass, 1/8 x 1/8 x 1/8 NPT Female
4	PG 3446	Nut, 1/4-20 Flange Hd Serrated
1	PG 3455	3/8" x 3/8" x 3/8" NPT Female
1	PG 3462	Tee Fitting, Hose 1/4"
1	PG 3464	Nolff N00-5101 1/4-28 to 1/4 I.D. Hose, Brass
1	PG 3466	Fitting, 1/8 NPT x 1/4 Barb
24	PG 3482	Hose, 3/16" Fuel Hose
2	PG 3487	1/4-20 x 3" Socket Head Cap Screw
1	PG 4089	ECM Cover
1	PG 7624	Plate, Top (LP)
1	PG 7638	Gasket, Throttle Body to Plate
1	PG 7655	EFI Malfunction Indicator Lamp Face Plate
7	PG 7656	Hose Clamp, 1/2" – 1 1/8" Clamp Dia
2	PG 7657	Hose Clamp, 1 5/16" – 3 1/4" Clamp Dia
1	PG 7663	GM 3.0L Manifold Adapter Plate
1	PG 7670	Throttle Body Assembly, 3.0
1	PG 7687	LP Lockoff Solenoid Valve for KEM
1	PG 7707	Gasket, 3.0L Intake Manifold
1	PG 7713	Nolff Mixer (CA100) w/Feedback Diaphragm
1	PG 7714	Nolff NJ – Vaporizer Regulator w/Blue Spring
1	PG 77350020	Harness, GM 3.0L LP
1	PG 9397	EFI Controller, ECM

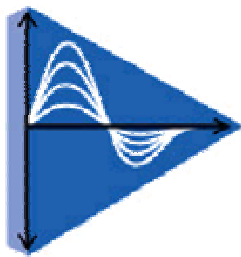


Nomenclatures typically used in EFI systems

CNG:	Compress Natural Gas
CTS:	Coolant Temperature Sensor
DBW:	Drive-by Wire
DIS:	Distributorless Ignition System
ECM:	Engine Control Module
ECT:	Engine Coolant Temperature
EFI:	Electronic Fuel Injection
ESA:	Electronic Spark Advance
GUI:	Graphical User Interface
HEGO:	Heated Exhaust Gas Oxygen (Oxygen sensor)
IAT:	Inlet Air Temperature
LED:	Light Emitting Diode
LP:	Liquid Propane/Liquid Petroleum
MAP:	Manifold Air Pressure
NG:	Natural Gas
PWM:	Pulse Width Modulated
TPS:	Throttle Position Sensor



Appendix



LPG FUEL SYSTEM RETROFIT

PROCEDURE

1. Remove the old fuel system throttle body assembly and electrical cable harness.
2. Check distributor cap and rotor.
3. Check spark plug wire, Replace if worn.
4. Check fuel lines and connectors for leaks.
5. Install the PG throttle body and mixer to the intake manifold.
6. Install the exhaust system including : the exhaust manifolds and catalytic converter (if required) and weld the O2 sensor weld boss to the exhaust manifold.
7. Verify the Spark Plugs Gap (0.030" typ.) and then install new spark plugs.
8. Install and verify the orifice hole 0.100" plug in the vacuum manifold hose to the PCV valve is correct.
9. Verify the Orifice size (0.060") to the tee adapter elbow on top port of the vaporizer is installed.
10. Install the PG electrical harness.
11. The harness should not be routed close to exhaust pipes ,or make sharp bends.
12. There should be sufficient length to flex across the stationary positions and the engine block.
13. Install Sensors:O2, map, air temp, coolant temp, oil pressure sender .
14. Assemble the throttle body inserting the gasket material and sealer between stages.
15. Install the vaporizer to the engine mount.
16. Install the LPG lock-off valve to the vaporizer.
17. Insert vacuum hoses and crank case vacuum hoses on the engine ports.
18. Check the air cleaner condition,replace if necessary.
19. The Map sensor must be connected to manifold vacuum.
20. The LPG fuel trim vacuum valve must be connected to the vacuum port at the LPG mixer.install the vapor line to the LP mixer .
21. Check vapor pressure line for leaks.
22. Assemble engine coolant hoses.
23. Connect all the sensors' connectors in place to the engine.
24. Check oil level and coolant level in engine.
25. Connect the ECM to the engine harness.
26. Unplug Actuator (if connected).
27. Start engine and warm-up with mechanical idle speed to approx. 750 rpm.
28. Adjust the minimum Air adjustment screw .
29. Tighten and lock the minimum idle speed adjustment screw..
30. Plug the connector back to the Actuator.
31. Test Throttle responsiveness and stability.
32. Verify that no exhaust leaks occurs before the O2 sensor.
33. Adjust Mixture till the O2 feedback is between 1.5 – 1.7.
34. Disconnect coolant temperature sensor. Stop Engine. Verify the error light flashes a code 15 OR the diagnostic error screen shows an error #15. This ensures the ECM is in timing check mode when the engine speed is below 1000 RPM.
35. Disconnect the actuator power.
36. Disconnect the O₂ sensor.
37. Start the engine.
38. Set engine speed to 750 RPM via idle screw.
39. Check timing is 0 degrees .
40. Do not exceed 1050 RPM when timing or it will exit timing mode.
41. Set minimum Air "Base Idle Speed"Customer Specific = 900 RPM.

Malfunction indicator light (MIL) function

This light is mounted on the dash for operator visual inspection upon powering the system with the ignition switch. This light displays error codes, if present, when the ignition switch is turned on, engine off. The codes are conveyed by flashing the light in such a manner that the first numeral is flashed, a pause, and then the second numeral of the code flashed.

The light will flash a code 12 every time the switch is moved to the on position; this indicates the system is in the diagnostic mode. When a code has been set, the code will be indicated after the code 12 is flashed. For instance, if a code 24 has been set, the light will flash one time, pause, two times, after which it will flash two times and then four times, indicating the code 24. If multiple codes are set they will be displayed in numerical order – not in order of occurrence.

Error codes	Error Description
12-	Diagnostic mode indicator
13-	Oxygen sensor error
14-	Engine coolant temp – high
15-	Engine coolant temp- low
21-	Throttle position sensor error
22-	Throttle body actuator not responding
23-	Inlet air temp sensor - low
24-	Inlet air temp sensor – high
25-	Electronic ignition control error
31-	Drive by wire error
32-	System voltage low
41-	Manifold absolute pressure sensor error
42-	Gasoline injector fault
51-	EPROM fault
52-	Analog to digital converter fault
61-	LP solenoid relay fault
62-	Fuel pump relay fault
63-	Dual fuel relay fault
Ignition power relay output error	

	DATE	INTERVAL HOURS								
		Daily	175	500	750	1250	1500	2000	3000	4000
GENERAL MAINTENANCE SECTION										
Inspect fuel system for leaks	Prior to any maintenance activity	X								
Inspect engine for fluid leaks		X								
Check engine oil		X								
Replace engine oil and filter			X							
Inspect accessory drive belts					X					
Inspect electrical system						X				
Inspect vacuum lines and fittings				X						
Inspect all fuel fittings and hoses			X							
Check engine compression pressure									X	
ENGINE COOLANT										
Check Engine Coolant Level		X								
Replace Coolant								X		
Inspect coolant hoses for leaks, cracks, swelling, or deterioration								X		
ENGINE IGNITION										
Inspect battery for case damage and corroded cables						X				
Inspect ignition system						X				
Check ignition timing - adjust as necessary	Service Dealer							X		
Replace spark plugs						X				
FUEL FILTER										
Check Fuel PSI Gasoline						X				
Replace fuel filter				X						
Inspect fuel lines and connections			X							
PRESSURE REGULATOR SECTION										
Test regulator pressure LPG/NG	Primary							X		
Inspect regulator for oil build-up	Service Dealer							X		
Inspect regulator assembly for fuel/coolant leaks								X		
FUEL INJECTION SYSTEM										
Check for air leaks in filter system								X		
Check for leaks on air intake system								X		
Check restriction indicator		X								
Inspect Air Cleaner			X							
Clean air filter element	Replace air filter as conditions require or at 500 hours									
Inspect air/gas valve assembly (Throttle)					X					
Inspect air/fuel mixture throat					X					
ENGINE EXHAUST SECTION										
Inspect Exhaust Manifold for leaks							X			
Inspect manifold-to-muffler exhaust piping and connections for leaks							X			
Inspect muffler for cracks and leaks								X		
Inspect catalyst inlet and outlet for leaks								X		
<p align="center">For application variables, reference your owners' manual.</p> <p align="center">**Please return to regular Hourly Maintenance intervals once 4000 hours have been reached**</p>										

Engine	1.6L	3.0L	4.3L	5.7L	8.1L
Type	1.6L L4	3.0L L4	4.3L V-6	5.7L V-8	8.1L V-8
Displacement CC	1598 (98)	2966 (181)	4294 (262)	5735 (350)	8127 (496)
Valve Configuration	Single Overhead Cam	Push Rod Actuated	Push Rod Actuated	Push Rod Actuated	Push Rod Actuated
Valve Lifters	Follower Hydraulic	Flat Follower	Hydraulic Roller	Hydraulic Roller	Hydraulic Roller
Bore x Stroke inches	3.11 X 3.20	4x3.6	4x3.48	4x3.48	4.25x4.37
Main Bearing Caps	2 bolt	2 bolt	2 bolt	2 bolt	4 bolt
Balance Method	Internal	External	Internal	External	External
Intake Manifold	Side Draft	Center Down Draft	Center Down Draft	Center Down Draft	Front Down Draft
Firing Order	1-3-4-2	1-3-4-2	1-6-5-4-3-2	1-8-4-3-6-5-7-2	1-8-7-2-6-5-4-3
Oil Capacity With Oil Filter	3.7 qts.	5 qts.	4.5 qts.	5 qts.	6 qts.
Oil Filter	PF-47	PF-25	PF-1069	PF-25	PF-454
Coolant Capacity Of Engine Block	N/A	4 qts.	7.75 qts.	8.1 qts.	14.5 qts.
Fuel Type	Gasoline, LPG	Gasoline, LPG	Gasoline, LPG	Gasoline, LPG, NG	Gasoline, LPG
Engine Rotation (Flywheel End)	CCW	CCW	CCW	CCW	CCW
Spark Plugs	93206675	AC Delco R46TS	AC Delco 41-932	AC Delco 41-932	AC Delco 41-983
Spark Plugs Gap	.030	.030	.030	.030	.030



Operation Manual

for

5.7L LPG AND CNG INJECTED

Mobile Alternative Fueled Engines

KEM EQUIPMENT INC.

10800 SW HERMAN RD.
TUALATIN, OR. 97062

PH# 503.692.5012 FAX# 503.692.1098

EMAIL: KEMPOWER@KEMEQUIPMENT.COM

WEB: WWW.KEMEQUIPMENT.COM

PC8031

EQUIPMENT QUICK REFERENCE

ENTER THE INFORMATION BELOW

EQUIPMENT MANUFACTURER

NAME _____

PH# _____

EQUIPMENT MODEL # _____

EQUIPMENT SERIAL # _____

ENGINE PART # _____

ENGINE SERIAL# _____

NOTES: _____

WARNING—DANGER OF DEATH OR PERSONAL INJURY



WARNING—FOLLOW INSTRUCTIONS

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.



WARNING—OUT-OF-DATE PUBLICATION

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, be sure to contact KEM Equipment. The revision level is shown at the bottom of the front cover after the publication number. If your publication is not there, please contact your customer service representative to get the latest copy.



WARNING—OVERSPEED PROTECTION

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.



WARNING—PROPER USE

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY



CAUTION—BATTERY CHARGING

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.



CAUTION—ELECTROSTATIC DISCHARGE

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.
- Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.

IMPORTANT DEFINITIONS

- A **WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
- A **CAUTION** indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment or property.
- A **NOTE** provides other helpful information that does not fall under the warning or caution categories.

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I. Introduction

KEM Equipment, Inc. is pleased that you have selected a **GM Powertrain** engine for your requirements. KEM Equipment, Inc. takes great pride in our tradition of quality products produced from the **GM Powertrain** line of industrial gasoline and alternative fuel engines.

KEM Equipment, Inc. engines are inspected and tested before leaving the factory. However, certain checks should be made before placing the engine into regular service. **Please read the initial start-up inspection requirements in the Maintenance section of this manual.**

A. How to Use this Manual

This manual contains instructions on the safe operation and preventive maintenance of your **GM Powertrain** industrial engine. We urge you to read this manual prior to start up of the engine.


The Table of Contents permits you to quickly open the manual to any section.

KEM Equipment, Inc. engines are built with a variety of standard and/or optional components to suit a broad range of customer requirements. This manual **does not** identify equipment as standard or optional. All the equipment described in this manual may or may not be found on your engine or power unit.

The description and specifications contained in this manual were in effect at the time of publication. KEM Equipment, Inc. reserves the right to discontinue models at any time, or to change specifications or design without notice and without incurring obligation.

II. Engine Identification

An identification placard is affixed to the engine. The label contains the engine family number and a part number, which identifies the engine from other KEM engines. The engine part number and serial number are required when seeking information concerning the engine and/or ordering replacement service parts.

KEM Equipment, Inc. 10800 SW Herman Rd. Tualatin, OR 97062		O			
Emission Control and Important Engine Information					
Engine Family		Max. Rated HP		Engine Useful Life	
BOX 1		BOX 2		5000 HRS / 7 YEARS	
KEM Engine P/N		MFG. Date		Serial Number	
BOX 3		BOX 4		BOX 5	
Engine Disp.		Emission Standards		Emission Control System	
L.		2.7 G/KW-HR HC + NOX		ECM, HO2S, TWC, SFI, MIX	
		4.4 G/KW-HR CO		Operating Fuel LPG or CNG	
Tune Up Specifications		See Owner's Manual			
<small>THIS ENGINE IS EQUIPPED WITH AN ALTERNATIVE FUEL SYSTEM. THIS ENGINE IS CERTIFIED TO OPERATE ON LPG FUEL OR CNG FUEL AND COMPLIES WITH APPLICABLE CALIFORNIA AND U.S. EPA REGULATIONS RELATED TO NEW 2007 AND LATER OFF-ROAD LARGE SPARK IGNITION ENGINES OF 25 HP AND GREATER.</small>					

Box # 1 ENGINE FAMILY is the number that is registered for certification.

Box # 2 MAXIMUM RATED HP is the horsepower rating for the certified engine.

Box # 3 KEM ENGINE P/N this is the part number for the engine, and this number should be recorded for ease of obtaining information or parts for this engine.

Box # 4 MFG. DATE is the date that this engine was manufactured at KEM Equipment.

Box # 5 SERIAL NO. This number identifies each individual engine. This number should also be recorded for the ease of obtaining information or parts for this engine

A. Parts and Service

Replacement parts can be obtained from KEM Equipment, Inc. by calling the Parts Department. The engine part number and serial number will be required when seeking information and/or ordering parts.

Technical support for KEM POWER engines can be obtained by contacting KEM Equipment Inc.

B. Service Literature

Parts and Service manuals for KEM POWER engines can be purchased by contacting the Parts Department.

III. Starting the Engine



WARNING: All internal combustion engines give off various fumes and gases while running. Do not start or run the engine in a closed or poorly ventilated area where exhaust gases may accumulate. Avoid breathing these gases as they may contain poisonous carbon monoxide and other gases, which can endanger your health or life if inhaled steadily for a few minutes.



CAUTION: If the engine stalls or falters during starting, wait 3 to 4 seconds before reengaging the starter. This will prevent possible damage to the starter or the engine. Do NOT operate the starter for periods longer than 30 seconds at a time. An interval of at least 1-minute should be observed between cranking periods to protect the starter from overheating.

If the engine is equipped with a manual clutch it must be disengaged prior to starting the engine. Starting the engine with the clutch engaged imposes unnecessary strain on the battery, starter, and driven components.

A. Fuel System Supplier

KEM supplies the EFI engine management system. These engine management systems are available in LPG or CNG fuel configurations. Using a MEFI 5 ECM and GFI Fuel Injectors.

B. Malfunction Indicator Light



NOTE: The lamps will not flash the error codes. To retrieve and reset the error codes a diagnostic scan tool is required. Some equipment manufacturers are using CAN-BUS displays that can retrieve the error codes. See the equipment manufacturers instructions to retrieve the error codes with their device.

There are two lights on the dash to indicate engine related problems. The operator is responsible to scan for illuminated bulbs during the course of engine operation.

The first indicator is the MIL – this is the Malfunction Indicator Light. The MIL conveys to the operator that a fault exists that is related to the emissions control system. When this light is illuminated a fault code has been set that requires immediate attention or engine component damage could conceivably occur.

Please stop operation of engine as soon as safely possible. Request that a technician inspect the fault code setting, he or she will connect a scan tool to determine the cause of the MIL illuminating, repair the problem and clear the codes. The MIL related codes are caused by sensor output and/or conditions that adversely affect the emissions output of the engine. Some of the components that can cause problems are: crank sensor, cam sensor, fuel injectors, regulators, O2 sensors (pre or post), ignition system and MAP sensor.

The second indicator is the Check Engine light. This bulb will illuminate when a non-emissions related issue occurs. Items that can cause these codes are high or low - oil pressure and coolant temperature. Various power relays operation, system voltage etc. The lighting of this fault indicator would indicate to the operator that the gauges for oil pressure and coolant temperature should be checked immediately and action taken to eliminate engine damage. There are safeties in the calibration that will turn off the engine if the sensor output is out of the normal range (low oil pressure when the engine is at rated speed for instance). If the engine should turn off for no apparent reason check this lamp. Similar to the MIL, the fault code will have to be read and cleared before continuing vehicle operation (after repairing the root problem).

IV. Stopping the Engine



WARNING: Avoid injury when checking a hot engine. Allow the engine to cool down before removing the radiator cap.



CAUTION: Before restarting the engine ensure that both the coolant system and the engine oil level have been checked and re-filled if necessary.

A. Normal Conditions

Following normal operating conditions, **lower the engine speed to idle**, pushing the throttle cable in on mechanical systems or with electronic systems return to idle.

If the machine is equipped with a clutch, move the clutch lever to the disengaged position.

Run the engine for a few minutes at idle to allow the coolant system to cool down before turning the ignition switch to the OFF position.

V. Maintenance Instructions

A. Initial Start Up Maintenance

The initial start-up checks must be made before putting the engine into service. Please refer to the Maintenance Schedule on page 15 and perform the initial start-up operations in the sequence shown in column 1.

B. Routine Maintenance

Routine maintenance provides the best solution for making sure that the engine is ready when you are. The following are some routine service points:

- Keep the fuel tank filled. A full tank of fuel reduces the possibility of condensation forming in the fuel tank and moisture entering the fuel system.
- Make frequent checks for engine oil and coolant leaks
- Repair any oil or coolant leaks
- Check battery condition and cables frequently
- Keep the engine air filter clean
- Monitor engine coolant temperature
- Monitor engine oil pressure
- Check voltmeter and charging system

C. Scheduled Preventive Maintenance

Refer to the Maintenance Schedule on page 15 to ensure that all of the maintenance items listed are checked and replaced at the recommended hours.

D. Engine Oil Level Check



CAUTION: Do not operate the engine with the oil level below the bottom of the dipstick or 'Add' mark on the dipstick, or above the top or 'Full' mark on the dipstick.

The engine oil level should be checked daily. It is recommended that the oil be checked just before the engine is started for the first time for the day. The oil level should be between the 'ADD' and the 'FULL' marks on the dipstick.

E. Adding Engine Oil

It is normal to add some oil in the period of time between oil changes. The amount will vary with the severity of operation. When adding or replacing engine oil, be sure the oil meets or exceeds the recommended specification.

VI. Changing Engine Oil and Filter

Under normal operating conditions, the engine oil and filter must be changed every 175 hours or every 3 months whichever occurs first. Use of premium quality oil and filters is recommended.

The oil and filter should be changed more often if the engine is operating in severe conditions, such as dirty areas, or during cold weather. No oil additives or break-in oil are recommended.

A. Engine Oil Quality



Important: use only engine oils displaying the American Petroleum Institute (API) “Starburst” Certification Mark **“FOR GASOLINE ENGINES”** on the container.

To achieve proper engine performance and durability, it is important that you use only engine lubricating oils of the correct type in your engine. Quality oil also provides maximum efficiency for crankcase ventilation systems, which reduces pollution.

Gasoline engines that are converted for Liquid Propane Gas or Natural Gas fuel **MUST** use oils labeled ‘**FOR GASOLINE ENGINES**’. Do not use oils that are specifically formulated for Diesel Engines only. CC or CD classification oils, even when labeled Heavy Duty or for Natural Gas Engines, **ARE NOT ACCEPTABLE**.

B. Engine Oil Recommendation

Multi-viscosity oils are recommended, SAE 10W-30 is recommended for your engine from 0 degrees F (-18 degrees C) or above. If ambient temperature are consistently below 0 degrees F, SAE 5W-30 oil should be used. Synthetic oils are not recommended for industrial or stationary engines.

C. Oil Filter



Important: Ensure the old filter gasket is removed prior to installing the new filter

The KEM **GM Powertrain** engines use an AC Delco (or equivalent) oil filter as original equipment. An equivalent oil filter must be used when servicing the engine (see Engine Specification for the recommended oil filter for your engine).

The filter protects your engine from harmful, abrasive, or sludgy particles without blocking the flow of oil to vital engine parts.

To replace the filter, use a proper filter wrench to remove the filter. Clean the filter-mounting base and lightly coat the gasket surface of the new filter with engine oil. Hand tighten the filter until the gasket contacts the base, then tighten another ½ turn. Fill the engine with the correct amount of oil, run the engine and check for oil leaks at the drain plug and filter gasket. Tighten as necessary to stop any oil leakage.

VII. Engine Air Cleaner



CAUTION: Service the air cleaner more frequently under severely dusty or dirty conditions.

The engine air cleaner filters air entering the engine intake system and acts as a silencer and flame arrester when assembled to the intake system.

Air that contains dirt and grit produces an abrasive fuel mixture, which may cause severe damage to the cylinder walls and piston rings. Damage to the cylinder walls and piston rings will cause high oil consumption and shorten engine life. A restricted or dirty air cleaner will cause a rich fuel mixture and rough engine operation. Thus, it is extremely important that the air cleaner be serviced properly at the recommended intervals.

Remove the primary air cleaner element from the air cleaner assembly and inspect the element for foreign material restrictions or signs of excessive wear or damage. Replace the element if necessary.

Remove all dust and foreign matter from air cleaner housing.

Reinstall the air cleaner element. Reinstall the air cleaner cap, and securely fasten the retaining clips.

IIIX. Cooling System



WARNING: Never remove the radiator cap under any condition while the engine is operating. Failure to follow these instructions could result in damage to the cooling system, engine, or cause personal injury.



CAUTION: DO NOT add coolant to any engine that has become overheated until the engine cools. Adding coolant to an extremely hot engine can result in a cracked block or cylinder head.

A. Coolant Level

Check the coolant level of the radiator daily and only when the engine is cool. Generally a good time to do this is just prior to starting the engine for the first time each day.

Maintain the coolant level at $\frac{3}{4}$ to $1\frac{1}{2}$ inches below fill neck seat of the radiator when the coolant is cold, but make sure core is covered. Whenever coolant level checks are made, inspect the condition of the radiator cap rubber seal. Make sure it is clean and free of any dirt particles, which would keep it from seating on the filler neck seat. Rinse off with clean water if necessary. Also make sure that the filler neck seat is free of any dirt particles. Use only permanent-type coolant when refilling or flushing the coolant system. Recommended ethylene glycol mix 50/50 is normal up to a maximum of 60% glycol, 40% water.



Caution: DO NOT mix DEX-COOL (pink/orange colored) with traditional (green) ethylene glycol. Refer to the mixture chart on the container for additional antifreeze protection information. DO NOT use alcohol or methanol antifreeze, or mix them with the specified coolant. Plain water may be used in an emergency (except in freezing temperatures), but replace it with the specified coolant as quickly as possible to avoid damage to the system.

B. Radiator

Inspect the exterior of the radiator for obstructions. Remove all bugs, dirt or foreign material with a soft brush or cloth. Use care to avoid damaging the core fins. If available, use low-pressure compressed air or a stream of water in the opposite direction of the normal airflow.

Check all hose and connections for leaks. If any of the hoses are cracked, frayed, or feel spongy, they must be replaced.

C. Fan Belts

The water pump is usually belt driven. The same belt may also drive the fan and/or the alternator. The drive belts should be properly adjusted at all times. A loose belt can cause improper alternator, fan and water pump operation, in addition to overheating.

D. Serpentine Belt

Some **GM Powertrain** engines utilize serpentine belts on the front of the engine. This type of belt system incorporates a belt-tensioning device that keeps the belt at the proper tension. No adjustments are necessary.

This belt should be checked routinely for cracks or 'checking' on the groove side of the belt. If cracks or 'checking' are apparent the belt must be changed.

IX. Fuel Injected Engines



CAUTION: Failure to change the fuel system filter as recommended can result in premature failure of fuel injection system components.



WARNING: Use extreme care when changing the fuel filter. LPG and CNG is highly flammable and under pressure. It should not be exposed to open flame, sparks, or hot engine components. Allow the engine to cool to ambient temperature prior to changing fuel filters.



WARNING: Fuel is under HIGH pressure, consult equipment dealer before servicing fuel system.

A: Fuel filter is used in the fuel supply line to the engine. This helps prevent contaminants from plugging the fuel injectors. The fuel filter is located in the supply line between the fuel tank and the engine. This filter protects the fuel injectors from debris in the fuel tank. This filter must be changed every 500 hours or every 6 months whichever ever occurs first.

B. Power Loss at Higher Elevations

Fuel injected engines will lose 3.5% power for every 1000 feet the engine is operated above sea level. All fuel injection systems installed by KEM Equipment, Inc. are equipped with a "manifold absolute pressure sensor" (MAP Sensor). The MAP sensor senses barometric pressure and automatically corrects the fuel system calibration for changes in altitude. This means the air/fuel mixture will always be optimized, regardless of elevation (or barometric pressure), however, the engine will still lose 3.5% power for every 1000 FT. increase in elevation.

All engines will experience power loss when operated at elevations above sea level, unless they are turbocharged or supercharged. Turbochargers and superchargers are mechanical pumps that put extra air into the engine to make up for the lower air density at higher elevations.

X. Ignition System



WARNING: High voltage ignition system. Electrical shock hazard.

A. Types of Ignition Systems

Three types of ignition systems are used on KEM engines. Solid state electronic distributor, electronic distributor with Electronic Control Module (ECM) and distributor-less electronic ignition with ECM.

B. Ignition Timing



CAUTION: Tampering will cause poor engine performance or failure. An authorized KEM EQUIPMENT, INC. dealer must perform checking or adjustment.

Ignition timing was set at the factory and requires no in-field adjustment.

XI. Spark Plugs



CAUTION: Always use the recommended spark plug for your engine, hotter or colder plugs, or similar plugs that are not exact equivalents to the recommended plugs, can cause permanent engine damage, reduce the engines useful life, and cause many other problems such as hard starting, spark knock and run-on, premature failure of catalyst and exhaust emissions may occur.

Spark plugs should be replaced at the recommended intervals as described in the Maintenance Schedule on page 15. Use only the recommended spark plugs or an equivalent as described in the General Specifications.

Spark plug gap should be adjusted as recommended in the General Specifications.

XII. Fuel Recommendation



WARNING : LPG and CNG fuels have the potential of causing severe burns if it contacts your skin.

A. LPG Fuel Specification



WARNING: LPG vehicles carry liquefied petroleum gas stored at pressures up to 200 psi. And even though LPG is inherently safe, extra caution should be used when performing any service or maintenance operation. Leakage of high-pressure gas can cause serious injury. Never attempt to service a LPG vehicle until the system pressure has been safely vented. Always vent system pressure in a well-ventilated area.

The KEM fuel system was designed for use with LPG fuel that complies with HD5 or HD10 LPG fuel standards. Use of non-compliant LPG fuel may require more frequent service intervals and will disqualify the user from warranty claims.

B. CNG Fuel Specification



WARNING: HIGH PRESSURE CNG vehicles carry natural gas stored at pressures up to 3600 psi. And even though CNG is inherently safe, extra caution should be used when performing any service or maintenance operation. Leakage of high-pressure gas can cause serious injury. Never attempt to service a CNG vehicle until the system pressure has been safely vented. Always vent system pressure in a well-ventilated area.

The KEM fuel system was designed for use with CNG that complies with the Society of Automotive Engineers (SAE) established standard. This standard is, minimum methane content of 95% (SAE J1616).

C. Fuel Quality Changes



NOTE: Sudden changes in fuel quality, including geographical regions may effect engine operation. A nominal period of time may be required for the engines emissions control system to self learn and adjust to the changes.

If proper engine operation does not resume within one hour contact our service dept. for additional support.

XIII. Specifications:

QUICK REFERENCE CHART	
Engine	5.7L
*OIL FILTER (BLOCK MOUNT)	*PF-25
**OIL FILTER (REMOTE MOUNT)	**PF-2
LP HIGH PRESSURE FILTER	A3-514
LP REGULATOR FILTER	A7-170
CNG HIGH PRESSURE FILTER	SEE EQUIPMENT MFG
CNG LOW PRESSURE FILTER	A3-546
AIR FILTER	SEE EQUIPMENT MFG
DIST. CAP	10452459
DIST. ROTOR	10452457
SPARK PLUGS	41-993
SPARK PLUG GAP	.040
PCV VALVE	2-9210

GENERAL ENGINE SPECIFICATIONS	
Engine	5.7L
TYPE	V-8
DISPLACEMENT	350 CID
VALVE CONFIGURATION	PUSHROD ACTUATED
VALVE LIFTERS	HYDRAULIC ROLLER
BORE X STROKE INCHES	4.00X3.48
BALANCE METHOD	EXTERNAL
INTAKE MANIFOLD	CENTER DOWN DRAFT
FIRING ORDER	1-8-4-3-6-5-7-2
OIL CAPACITY W/FILTER	6 QTS
FUEL TYPE	LPG
ENGINE ROTATION	CCW

FUEL PRESSURES	
INJECTOR RAIL	
LPG	15 PSI
CNG	25 PSI

*Standard GM mounting location ** KEM supplied remote filter assembly

MAINTENANCE SCHEDULE									
CHECK POINT	INTERVAL HOURS								
	DAILY	EVERY 175 HOURS OR 1 MONTH	EVERY 500 HOURS OR 3 MONTHS	EVERY 750 HOURS OR 4 MONTHS	EVERY 1000 HOURS OR 6 MONTHS	EVERY 1250 HOURS OR 8 MONTHS	EVERY 1500 HOURS OR 9 MONTHS	EVERY 2000 HOURS OR 12 MONTHS	EVERY 3000 HOURS OR 18 MONTHS
GENERAL MAINTENANCE									
Inspect fuel system(s) for leaks	PRIOR TO ANY SERVICE OR MAINTENANCE ACTIVITY								
Inspect engine for fluid leaks	X								
Check engine oil	X								
Replace engine oil and filter		X							
Inspect accessory drive belt(s)				X					
Inspect vacuum lines and fittings			X						
Inspect all fuel hoses and fittings		X							
Inspect ECM isolation mounts for cracks and wear; replace as necessary			X						
Inspect foot pedal travel and operation	X								
Check for MIL lamp test at key-on. If MIL lamp remains illuminated (it is indicating a fault), refer to page 20	X								
Check engine compression									X
Replace timing belt									
ENGINE COOLANT									
Check engine coolant level	X								
Replace Coolant								X	
Inspect coolant hoses for leaks, cracks, swelling, or deterioration					X				
ENGINE IGNITION									
Inspect battery for case damage and corroded cables						X			
Inspect ignition system						X			
Replace spark plugs						X			
LPG FUEL SYSTEM									
Replace (LP) fuel filter			X						
Inspect fuel lock-off and fuel filter for leaks			X						
Ensure lock-off stops fuel flow when engine is off					X				
Test Regulator pressures					X				
Inspect pressure regulator vapor hose for deposit build-up. Clean or replace as necessary.					X				
Inspect regulator for fuel/coolant leaks					X				
Inspect injector hoses for wear, cracks, or deterioration.					X				
CNG FUEL SYSTEM									
Replace (CNG) fuel filter			X						
Inspect fuel lock-off and fuel filter for leaks			X						
Ensure lock-off stops fuel flow when engine is off					X				
Test Regulator pressures					X				
Inspect pressure regulator vapor hose for deposit build-up. Clean or replace as necessary.					X				
Inspect regulator for fuel/coolant leaks					X				
Inspect injector hoses for wear, cracks, or deterioration.					X				
CARBURETOR & AIR FILTRATION									
Check air filter restriction indicator	X								
Check for leaks in air intake and filtration system					X				
Inspect air filter element		X							
Clean air filter element	Replace air filter element as conditions require or at 500 hrs								
Inspect air/gas valve (throttle body)				X					
ENGINE EXHAUST SYSTEM									
Inspect engine for exhaust leaks	X								
Inspect Catalyst/Muffler for cracks, leaks, and damage.					X				

XIV. WARRANTY

A. CERTIFIED EMISSIONS INDUSTRIAL ENGINE LIMITED WARRANTY

1. KEM Equipment, Inc. "the company" warrants each new Industrial engine, and factory installed accessories, to be free from defects in material and workmanship for the life of the warranty.
2. The warranty shall be in force only after KEM receives a properly completed Warranty Registration Form from the original purchaser. The Warranty commences on the date of the first retail purchase and applies to the original and subsequent purchasers. However, in no event shall the duration of the Warranty exceed three (3) years or 2500 hours measured from the original retail sale date. All subsequent purchasers must inform KEM in writing of the sale of the engine (and pay a \$150.00 transfer fee) to continue the warranty. If notification and payment is not received by KEM within 30 days of the resale, the warranty will be null and void.
3. The company obligation is limited to repairing or replacing those parts that are defective in material and workmanship only. At KEM's option it may replace such part with a part of equal quality to remedy any malfunction resulting from a defect in material or workmanship. Optionally, KEM may provide for the repair or replacement of any defective part at the selling dealership or a service center of KEM'S choice. KEM will make payment reimbursements for labor to replace such part as previously provided in the then current flat rate manual.
4. KEM distributors or service centers must be advised of any warranty related problem prior to the expiration of the warranty.
5. This warranty will **not** apply to:
 - **Use of accessories or parts not manufactured or sold by KEM Equipment, Inc.**
 - **Neglect; failure to follow maintenance schedules; accident; abnormal operation; misuse or negligence; improper maintenance or installation; racing or unapproved engine modifications.**
 - **Problems arising from incorrect installation or modifications to the exhaust components, fuel lines, cooling system components; or engine damage due to incorrect electrical connections.**
 - **Rust, corrosion, invasion effects of weather, or electrolysis.**
 - **Detonation or operation with fuels, oils or lubricants, which are not suitable for use with this product. Detonation causes: Poor fuel quality, overloading of engine, improper gear, engine overheating, excessive back pressure, incorrect ignition timing.**
 - **Reimbursement for: Storage charges, rental charges of any type, inconvenience of any type, loss of time or income, expense of returning KEM product to a service facility, towing, lodging, travel time, loss or damage to personal property.**
6. Reasonable access must be provided to the product for warranty service.

7. Warranty service must be requested by delivering the product for inspection to the retailer from whom the product was purchased or any convenient Industrial Service Center.
8. Proof of warranty must be provided at time of request for warranty service. A properly completed warranty registration must be on file with KEM.
9. Accurate service records must be available at the time of a warranty request.
10. Distributors, dealers and service providers are not agents for KEM. The company's obligation under this warranty is strictly and exclusively limited to the repair or replacement of defective parts and does not authorize any person to create for it any obligation of liability in connection with this product nor does the company assume any obligation due to incorrect or defective installation by the dealer.
11. All incidental and/or consequential damages are excluded from this warranty. Implied warranties are limited to the life of this warranty. All implied warranties including merchantability fitness for a particular purpose or otherwise are disclaimed in their entirety after expirations of the appropriate 3 year / 2500 hour warranty period. This warranty gives you specific rights, and you may also have other rights, which may vary from state to state.
12. KEM reserves the right to change or improve design of any product previously assembled without notice and without obligation.
13. In the event that a warranty claim is required outside of the continental United States, with the exception of Alaska, Hawaii and Canada there may be additional charges to the engine owner. KEM will not warranty any engine outside the continental United States, with the exception of Alaska, Hawaii and Canada unless competent and trained personnel are available to provide service to the engine.

B. Emission Control Warranty

General Emissions Warranty Coverage

KEM Equipment, Inc. warrants to the ultimate engine purchaser and each subsequent purchaser that the Off-Road Large Spark-Ignition engines produced and certified by KEM Equipment, Inc. are designed, built, and equipped so as to conform to all applicable California ARB and U.S. EPA regulations. KEM warrants that all such engines are also free from defects in materials and workmanship.

Your Warranty Rights and Obligations

The California Air Resources Board, U.S. EPA and KEM Equipment, Inc. are pleased to explain the emission control system warranty on your new 2007 and subsequent model year Off-Road Large Spark-Ignition (LSI) engine. New LSI engines must be designed, built and equipped to meet stringent Federal and State anti-smog standards. KEM Equipment, Inc. must warrant the emission control system on your engine for the periods of time listed provided there has been no abuse, neglect or improper maintenance of your engine.

The emission control system on your new LSI engine may include parts such as the mixer, regulator or fuel injection system, ignition system, engine computer module (SECM), catalytic converter and air induction system. Also included may be sensors, hoses, belts, connectors and other associated emission-related assemblies. Please see **Emission Warranty Parts List** for a full disclosure of those parts covered under this Emission Control Warranty.

Where a warrantable condition exists, KEM Equipment, Inc. will repair your LSI engine at no cost to you including diagnosis, parts, and labor (travel expenses excluded).

KEM Equipment Inc. Warranty Coverage:

The new 2007 and subsequent model year off-road large spark-ignition engines are warranted for 3 years or 2500 hours of service, whichever occurs first from the date the equipment is delivered to the first retail purchaser or when the equipment is first placed in service. If any emission-related part on the engine is determined to be defective, the part will be repaired or replaced at no cost to you at an authorized KEM Equipment, Inc. service facility.

Owner's Warranty Responsibilities

As the off-road LSI engine owner, you are responsible to perform the **required maintenance listed in your owner's manual**. KEM Equipment, Inc. recommends that you retain all records covering maintenance on your off-road engine, but KEM Equipment, Inc. cannot deny warranty solely for the lack of receipts or for your failure to perform all scheduled maintenance.

As the off-road large spark-ignition engine owner, you should however be aware that KEM Equipment, Inc. may deny you warranty coverage if your off-road large spark ignition engine or a part has failed due to abuse, neglect, improper maintenance, unapproved modifications, or use of fuel(s) not in compliance with KEM's recommended fuel specifications.

You are responsible for initiating the warranty process. KEM suggests that you present your off-road large spark-ignition engine to an authorized KEM Equipment, Inc. dealer as soon as a problem exists. The warranty repair should be completed by the dealer as expeditiously as possible.

If you have any questions regarding your warranty rights and responsibilities, you should contact KEM Equipment, Inc. at (503) 692-5012.

General Emissions Warranty Coverage

Any warranted part that is not scheduled for replacement as required maintenance in the written instructions provided by KEM Equipment, Inc. will be warranted for the warranty period specified in this document. If any such part fails during the period of warranty coverage, it will be repaired or replaced by KEM Equipment Inc. according to the provisions contained herein. Any such part repaired or replaced under the warranty will be warranted for the remaining warranty period.

Any warranted part that is scheduled only for regular inspection in the written maintenance instructions to the effect of "repair or replace as necessary" will not reduce the period of warranty coverage. Any such part repaired or replaced under warranty will be warranted for the remaining warranty period.

Any warranted part that is scheduled for replacement as required maintenance in the written instructions will be warranted for the period of time prior to the first scheduled replacement point for that part. If the part fails prior to the first scheduled replacement, the part will be repaired or replaced by KEM Equipment, Inc. according to the procedures specified in this document. Any such part repaired or replaced under warranty will be warranted for the remainder of the period prior to the first scheduled replacement point for the part.

Repair or replacement of any warranted part under the warranty provisions will be performed at no charge to the owner at a warranty station.

Warranty services or repairs will be provided at all manufacturer distribution centers that are franchised to service the subject engines.

The owner will not be charged for diagnostic labor that leads to the determination that a warranted part is in fact defective, provided that such diagnostic work is performed at a warranty station.

KEM Equipment, Inc. will be liable for damages to other engine components proximately caused by a failure under warranty of any warranted part provided by KEM Equipment, Inc.

Throughout the engine's warranty period defined, KEM Equipment, Inc. will maintain a supply of warranted parts sufficient to meet the expected demand for such parts.

Any replacement part, as defined in California Code of Regulations Section 1900 (b) (13), Title 13, may be used in the performance of any maintenance or repairs and will be provided without charge to the owner. It is not necessary for replacement parts to be the same brand or by the same manufacturer as the original part sold with the engine. Such use will not reduce the warranty obligations of KEM Equipment, Inc.

ADD-on or modified parts, as defined in California Code of Regulations Section 1900 (b) (1) and (b)(10), Title 13, may not be used. Such use will, at the discretion of KEM Equipment, Inc., be grounds for disallowing a warranty claim. KEM Equipment, Inc. will not be liable under this article to warrant failures of warranted parts caused by the use of such an add-on or modified part.

C. Emission Warranty Parts List

Warranty 3 years or 3,500 hours

1. Base Engine
 - a. GM Base Engine Assembly

Warranty 3 years or 2,500 hours

1. Fuel Metering System
 - a. Fuel injection system
 - b. Air/fuel ratio feedback and control system
 - c. Carburetor system (internal parts and/or pressure regulator or fuel mixer or injection system).
 2. Air Induction System
 - a. Intake manifold or air intake system
 3. Exhaust system
 - a. Catalytic converter
 - b. Exhaust manifold
 4. Positive Crankcase Ventilation (PCV) System
 - a. PCV Valve
 - b. Oil Filler Cap
 5. Ignition Control System
 - a. Engine Control Module (ECM)
 - b. Ignition module(s)
 6. Miscellaneous items Used in Above Systems (Unless a normal wear item)
 - a. Vacuum, temperature, and time sensitive valves and switches.
 - b. Sensors used for electronic controls
 - c. Hoses, belt connectors, assemblies, clamps, fittings, tubing, sealing gaskets or devices, and mounting hardware
 - d. Pulleys, belts and idlers
-

XIV. Diagnostic Error Codes



WARNING: Fire, Shock, and Burn Danger: When performing any diagnostics or service work use caution. This system has extreme fuel pressures and a high voltage ignition.



CAUTION: Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).

Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.

Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.

Powertrain On Board Diagnostic (OBD) System Check

1. Verify that none of the following preliminary inspections/tests reveal the cause of the vehicle concern before beginning diagnosis:

- Ensure that the battery is fully charged.
- Ensure that the battery cables are clean and tight.
- Inspect for any open fuses. Refer to *Engine Controls Schematics*.
- Ensure that the grounds are clean, tight, and in the correct location.
- Inspect the easily accessible systems or the visible system components for

obvious damage or conditions that could cause the concern. This would include checking to ensure that all connections/connectors are fully seated and secured.

- Inspect for aftermarket devices that could affect the operation of the system.

Refer to *Checking Aftermarket Accessories*.

- Search for applicable service bulletins.

If the preceding inspections/tests resolve the concern, go to *Diagnostic Repair Verification*.

2. Install a scan tool. Verify that the scan tool powers up.

If the scan tool does not power up, refer to *Scan Tool Does Not Power Up*.

3. Ignition ON, Engine OFF, verify communication with all of the control modules on the vehicle.

If the scan tool does not communicate with one or more of the expected control modules, refer to *Scan Tool Does Not Communicate with CAN Device*.

4. Verify that SPN 65559 is not set.

If SPN 65559 is set, refer to *SPN 65559*.

5. Attempt to start the engine. Verify that the engine cranks.

If the engine does not crank, refer to *SPN 66001* or *SPN 66002* (if equipped). If the vehicle is not equipped with an ECM controlled starter relay, repair the starting system.

6. Attempt to start the engine. Verify the engine starts and idles.

If the engine does not start and idle, refer to *Engine Cranks But Does Not Run*.

Important: Do not clear any SPNs unless instructed to do so by a diagnostic procedure.

7. Use the appropriate scan tool selections to obtain SPNs from each of the vehicle modules. Verify there are no SPNs reported from any module.

If any SPNs are present, refer to *Diagnostic Trouble Code (DTC) List* and diagnose any current SPNs in the following order:

7.1. Any of the following: 630, 65580, 65581, or 65582.

7.2. SPN 627.

7.3. Component level SPNs.

7.4. System level SPNs.

7.5. Any remaining SPNs.

If none of the previous tests or inspections addresses the concern, refer to *Symptoms - Engine Controls*.

SPN 38 or 96

SPN Descriptors

SPN 38 FMI 3: Fuel Level Sensor 2 Circuit Voltage Above Normal or Shorted High

SPN 38 FMI 4: Fuel Level Sensor 2 Circuit Voltage Below Normal or Shorted Low

SPN 96 FMI 3: Fuel Level Sensor 1 Circuit Voltage Above Normal or Shorted High

SPN 96 FMI 4: Fuel Level Sensor 1 Circuit Voltage Below Normal or Shorted Low

SPN 84

SPN Descriptors

SPN 84 FMI 1: Vehicle Speed Sensor (VSS) Data Valid but Below Normal

SPN 84 FMI 2: Vehicle Speed Sensor (VSS) Data Erratic, Intermittent or Incorrect

SPN 84 FMI 3: Vehicle Speed Sensor (VSS) Voltage Above Normal or Shorted High

SPN 84 FMI 4: Vehicle Speed Sensor (VSS) Voltage Below Normal or Shorted Low

SPN 94

SPN Descriptors

SPN 94 FMI 3: Fuel Pressure Sensor Voltage Above Normal or Shorted High

SPN 94 FMI 4: Fuel Pressure Sensor Voltage Below Normal or Shorted Low

SPN 94 FMI 15: Fuel Pressure Data Valid But Above Normal Range-Least Severe Level

SPN 94 FMI 17: Fuel Pressure Data Valid But Below Normal Range-Least Severe Level

SPN 98

SPN Descriptors

SPN 98 FMI 17: Oil Level Switch Signal Data Valid But Below Normal Range-Least Severe Level

SPN 100

SPN Descriptors

SPN 100 FMI 3: Engine Oil Pressure (EOP) Sensor Circuit Voltage Above Normal or Shorted High

SPN 100 FMI 4: Engine Oil Pressure (EOP) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 100 FMI 17: Engine Oil Pressure (EOP) Sensor Data Valid But Below Normal Range-Least Severe Level

SPN 105

SPN Descriptors

SPN 105 FMI 3: Manifold Air Temperature (MAT) Sensor Circuit Voltage Above Normal or Shorted High

SPN 105 FMI 4: Manifold Air Temperature (MAT) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 106

SPN Descriptors

SPN 106 FMI 0: Manifold Absolute Pressure (MAP) Sensor Circuit Voltage Data Valid But Above Normal

SPN 106 FMI 1: Manifold Absolute Pressure (MAP) Sensor Circuit Voltage Data Valid But Below Normal

SPN 106 FMI 3: Manifold Absolute Pressure (MAP) Sensor Circuit Voltage Above Normal or Shorted High

SPN 106 FMI 4: Manifold Absolute Pressure (MAP) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 108

SPN Descriptors

SPN 108 FMI 2: Barometric Pressure (BARO) Sensor Voltage Data Erratic, Intermittent or Incorrect

SPN 108 FMI 3: Barometric Pressure (BARO) Sensor Voltage Above Normal or Shorted High

SPN 108 FMI 4: Barometric Pressure (BARO) Sensor Voltage Below Normal or Shorted Low

SPN 108 FMI 10: Barometric Pressure (BARO) Sensor Abnormal Rate of Change

SPN 110

SPN Descriptors

SPN 110 FMI 3: Engine Coolant Temperature (ECT) Sensor Circuit Voltage Above Normal or Shorted High

SPN 110 FMI 4: Engine Coolant Temperature (ECT) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 110 FMI 15: Engine Coolant Temperature (ECT) Sensor Circuit Voltage Data Valid But Above Normal Range-Least Severe Level

SPN 174

SPN Descriptors

SPN 174 FMI 3: Fuel Temperature (FT) Sensor Circuit Voltage Above Normal or Shorted High

SPN 174 FMI 4: Fuel Temperature (FT) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 627

SPN Descriptors

SPN 627 FMI 15: System Voltage Data Valid But Above Normal Range-Least Severe Level

SPN 627 FMI 17: System Voltage Data Valid But Below Normal Range-Least Severe Level

SPN 630, 65580, 65581, or 65582

SPN Descriptors

SPN 630 FMI 13: Cal Memory Out of Calibration

SPN 65580 FMI 12: CPU Bad Intelligent Device or Component

SPN 65581 FMI 12: MHC Failure Bad Intelligent Device or Component

SPN 65582 FMI 12: NV RAM Failure Data Erratic, Intermittent or Incorrect

SPN 636

SPN Descriptors

SPN 636 FMI 2: Crankshaft Position (CKP) Sensor Circuit Data Erratic, Intermittent or Incorrect

SPN 636 FMI 8: Crankshaft Position (CKP) Sensor Signal Abnormal Frequency or Pulse Width

SPN 651, 652, 653, 654, 655, 656, 657, or 658

SPN Descriptors

SPN 651 FMI 3: Fuel Injector 1 Voltage Above Normal or Shorted High

SPN 651 FMI 5: Fuel Injector 1 Current Below Normal or Open Circuit

SPN 652 FMI 3: Fuel Injector 2 Voltage Above Normal or Shorted High

SPN 652 FMI 5: Fuel Injector 2 Current Below Normal or Open Circuit

SPN 653 FMI 3: Fuel Injector 3 Voltage Above Normal or Shorted High

SPN 653 FMI 5: Fuel Injector 3 Current Below Normal or Open Circuit

SPN 654 FMI 3: Fuel Injector 4 Voltage Above Normal or Shorted High

SPN 654 FMI 5: Fuel Injector 4 Current Below Normal or Open Circuit

SPN 655 FMI 3: Fuel Injector 5 Voltage Above Normal or Shorted High

SPN 655 FMI 5: Fuel Injector 5 Current Below Normal or Open Circuit

SPN 656 FMI 3: Fuel Injector 6 Voltage Above Normal or Shorted High

SPN 656 FMI 5: Fuel Injector 6 Current Below Normal or Open Circuit

SPN 657 FMI 3: Fuel Injector 7 Voltage Above Normal or Shorted High

SPN 657 FMI 5: Fuel Injector 7 Current Below Normal or Open Circuit

SPN 658 FMI 3: Fuel Injector 8 Voltage Above Normal or Shorted High

SPN 658 FMI 5: Fuel Injector 8 Current Below Normal or Open Circuit

SPN 3563

SPN Descriptors

SPN 3563 FMI 0: Supercharger Inlet Pressure (SCIP) Sensor Circuit Data Valid but Above Normal

SPN 3563 FMI 1: Supercharger Inlet Pressure (SCIP) Sensor Circuit Data Valid but Below Normal

SPN 3563 FMI 2: Supercharger Inlet Pressure (SCIP) Sensor Circuit Data Erratic, Intermittent, or Incorrect

SPN 3563 FMI 3: Supercharger Inlet Pressure (SCIP) Sensor Circuit Voltage Above Normal or Shorted High

SPN 3563 FMI 4: Supercharger Inlet Pressure (SCIP) Sensor Circuit Voltage Below Normal or Shorted Low

SPN 65541, 65542, 65543, 65544, 65545, 65546, 65547, or 65548

SPN Descriptors

SPN 65541 FMI 4: Ignition Coil 1 Voltage Below Normal or Shorted Low
SPN 65541 FMI 5: Ignition Coil 1 Current Below Normal or Open Circuit
SPN 65542 FMI 4: Ignition Coil 2 Voltage Below Normal or Shorted Low
SPN 65542 FMI 5: Ignition Coil 2 Current Below Normal or Open Circuit
SPN 65543 FMI 4: Ignition Coil 3 Voltage Below Normal or Shorted Low
SPN 65543 FMI 5: Ignition Coil 3 Current Below Normal or Open Circuit
SPN 65544 FMI 4: Ignition Coil 4 Voltage Below Normal or Shorted Low
SPN 65544 FMI 5: Ignition Coil 4 Current Below Normal or Open Circuit
SPN 65545 FMI 4: Ignition Coil 5 Voltage Below Normal or Shorted Low
SPN 65545 FMI 5: Ignition Coil 5 Current Below Normal or Open Circuit
SPN 65546 FMI 4: Ignition Coil 6 Voltage Below Normal or Shorted Low
SPN 65546 FMI 5: Ignition Coil 6 Current Below Normal or Open Circuit
SPN 65547 FMI 4: Ignition Coil 7 Voltage Below Normal or Shorted Low
SPN 65547 FMI 5: Ignition Coil 7 Current Below Normal or Open Circuit
SPN 65548 FMI 4: Ignition Coil 8 Voltage Below Normal or Shorted Low
SPN 65548 FMI 5: Ignition Coil 8 Current Below Normal or Open Circuit

SPN 65550, 65551, or 65552

SPN Descriptors

SPN 65550 FMI 2: Knock Sensor (KS) Circuit Data Erratic, Intermittent or Incorrect
SPN 65551 FMI 2: Knock Sensor (KS) Bank 1 Circuit Data Erratic, Intermittent or Incorrect
SPN 65552 FMI 2: Knock Sensor (KS) Bank 2 Circuit Data Erratic, Intermittent or Incorrect

SPN 65559

SPN Descriptors

SPN 65559 FMI 11: CAN Bus Hardware Fault Root Cause Unknown

SPN 65560

SPN Descriptors

SPN 65560 FMI 9: CAN Bus Governor Command Abnormal Update Rate

SPN 65561, 65562, 65563, or 65564

SPN Descriptors

SPN 65561 FMI 0: Oxygen Sensor Bank A Sensor 1 Data Valid But Above Normal
SPN 65561 FMI 1: Oxygen Sensor Bank A Sensor 1 Data Valid But Below Normal
SPN 65561 FMI 3: Oxygen Sensor Bank A Sensor 1 Voltage Above Normal or Shorted High
SPN 65561 FMI 4: Oxygen Sensor Bank A Sensor 1 Voltage Below Normal or Shorted Low
SPN 65561 FMI 5: Oxygen Sensor Bank A Sensor 1 Current Below Normal or Open Circuit
SPN 65562 FMI 0: Oxygen Sensor Bank A Sensor 2 Data Valid But Above Normal
SPN 65562 FMI 1: Oxygen Sensor Bank A Sensor 2 Data Valid But Below Normal
SPN 65562 FMI 3: Oxygen Sensor Bank A Sensor 2 Voltage Above Normal or Shorted High

SPN 65562 FMI 4: Oxygen Sensor Bank A Sensor 2 Voltage Below Normal or Shorted Low
SPN 65562 FMI 5: Oxygen Sensor Bank A Sensor 2 Current Below Normal or Open Circuit
SPN 65563 FMI 0: Oxygen Sensor Bank B Sensor 1 Data Valid But Above Normal
SPN 65563 FMI 1: Oxygen Sensor Bank B Sensor 1 Data Valid But Below Normal
SPN 65563 FMI 3: Oxygen Sensor Bank B Sensor 1 Voltage Above Normal or Shorted High
SPN 65563 FMI 4: Oxygen Sensor Bank B Sensor 1 Voltage Below Normal or Shorted Low
SPN 65563 FMI 5: Oxygen Sensor Bank B Sensor 1 Current Below Normal or Open Circuit
SPN 65564 FMI 0: Oxygen Sensor Bank B Sensor 2 Data Valid But Above Normal
SPN 65564 FMI 1: Oxygen Sensor Bank B Sensor 2 Data Valid But Below Normal
SPN 65564 FMI 3: Oxygen Sensor Bank 2 Sensor 2 Voltage Above Normal or Shorted High
SPN 65564 FMI 4: Oxygen Sensor Bank B Sensor 2 Voltage Below Normal or Shorted Low
SPN 65564 FMI 5: Oxygen Sensor Bank B Sensor 2 Current Below Normal or Open Circuit

SPN 65565 or 65566

SPN Descriptors

SPN 65565 FMI 0: Fuel Trim Bank 1 Data Valid But Above Normal
SPN 65565 FMI 1: Fuel Trim Bank 1 Data Valid But Below Normal
SPN 65566 FMI 0: Fuel Trim Bank 2 Data Valid But Above Normal
SPN 65566 FMI 1: Fuel Trim Bank 2 Data Valid But Below Normal

SPN 65567 or 65568

SPN Descriptors

SPN 65567 FMI 8: Oxygen Sensor Bank 1 Sensor 1 Abnormal Frequency or Pulse Width
SPN 65567 FMI 10: Oxygen Sensor Bank 1 Sensor 1 Abnormal Rate of Change
SPN 65568 FMI 8: Oxygen Sensor Bank 2 Sensor 1 Abnormal Frequency or Pulse Width
SPN 65568 FMI 10: Oxygen Sensor Bank 2 Sensor 1 Abnormal Rate of Change

SPN 65570

SPN Descriptors

SPN 65570 FMI 2: Cam Phaser W Data Erratic, Intermittent, or Incorrect
SPN 65570 FMI 4: Cam Phaser W Voltage Below Normal or Shorted Low
SPN 65570 FMI 5: Cam Phaser W Short High or Open
SPN 65570 FMI 7: Cam Phaser W Accuracy Mechanical System Not Responding or Out of Adjustment

SPN 65590, 65591, 65592, 65593, 65594, 65595, 65596, 65597, 65598, or 65599

SPN Descriptors

SPN 65590 FMI 7: Misfire Mechanical System Not Responding or Out of Adjustment
SPN 65591 FMI 7: Misfire Cylinder 1 Mechanical System Not Responding or Out of Adjustment
SPN 65592 FMI 7: Misfire Cylinder 2 Mechanical System Not Responding or Out of Adjustment
SPN 65593 FMI 7: Misfire Cylinder 3 Mechanical System Not Responding or Out of Adjustment

SPN 65594 FMI 7: Misfire Cylinder 4 Mechanical System Not Responding or Out of Adjustment

SPN 65595 FMI 7: Misfire Cylinder 5 Mechanical System Not Responding or Out of Adjustment

SPN 65596 FMI 7: Misfire Cylinder 6 Mechanical System Not Responding or Out of Adjustment

SPN 65597 FMI 7: Misfire Cylinder 7 Mechanical System Not Responding or Out of Adjustment

SPN 65598 FMI 7: Misfire Cylinder 8 Mechanical System Not Responding or Out of Adjustment

SPN 65599 FMI 7: Misfire Random Mechanical System Not Responding or Out of Adjustment

SPN 65601, 65602, or 65610

SPN Descriptors

SPN 65601 FMI 2: Throttle Position (TP) Sensor 2 Data Erratic, Intermittent or Incorrect

SPN 65602 FMI 2: Throttle Position (TP) Sensor 1 Data Erratic, Intermittent or Incorrect

SPN 65610 FMI 2: Throttle Position (TP) Sensor 1 and 2 Data Erratic, Intermittent or Incorrect

SPN 65604, 65605, or 65613

SPN Descriptors

SPN 65604 FMI 2: Pedal Position (PP) Sensor 2 Data Erratic, Intermittent or Incorrect

SPN 65604 FMI 12: Pedal Position (PP) Sensor 2 Bad Intelligent Device or Component

SPN 65605 FMI 2: Pedal Position (PP) Sensor 1 Data Erratic, Intermittent or Incorrect

SPN 65605 FMI 12: Pedal Position (PP) Sensor 1 Bad Intelligent Device or Component

SPN 65613 FMI 2: Pedal Position (PP) Sensor 1 and 2 Data Erratic, Intermittent or Incorrect

SPN 65615, 65616, or 65618

SPN Descriptors

SPN 65615 FMI 7: Electronic Throttle Control (ETC) Actuation Fault Mechanical System Not Responding or Out of Adjustment

SPN 65616 FMI 12: Electronic Throttle Control (ETC) Process Fault Bad Intelligent Device or Component

SPN 65618 FMI 7: Electronic Throttle Control (ETC) Return Fault Mechanical System Not Responding or Out of Adjustment

SPN 65620 or 65621

SPN Descriptors

SPN 65620 FMI 4: 5 Volt Reference A Circuit Voltage Below Normal or Shorted Low

SPN 65621 FMI 4: 5 Volt Reference B Circuit Voltage Below Normal or Shorted Low

SPN 65671 or 65672

SPN Descriptors

SPN 65671 FMI 0: Catalytic Converter A Temperature Sensor Data Valid But Above Normal

SPN 65671 FMI 1: Catalytic Converter A Temperature Sensor Data Valid But Below Normal

SPN 65671 FMI 3: Catalytic Converter A Temperature Sensor Voltage Above Normal or Shorted High

SPN 65671 FMI 4: Catalytic Converter A Temperature Sensor Voltage Below Normal or Shorted Low

SPN 65672 FMI 0: Catalytic Converter B Temperature Sensor Data Valid But Above Normal

SPN 65672 FMI 1: Catalytic Converter B Temperature Sensor Data Valid But Below Normal

SPN 65672 FMI 3: Catalytic Converter B Temperature Sensor Voltage Above Normal or Shorted High

SPN 65672 FMI 4: Catalytic Converter B Temperature Sensor Voltage Below Normal or Shorted Low

SPN 65673 or 65674

SPN Descriptors

SPN 65673 FMI 15: Catalytic Converter A Temperature Sensor Data Valid But Above Normal Range-Least Severe Level

SPN 65674 FMI 15: Catalytic Converter B Temperature Sensor Data Valid But Above Normal Range-Least Severe Level

SPN 65675 or 65676

SPN Descriptors

SPN 65675 FMI 11: Catalytic Converter A Efficiency Root Cause Unknown

SPN 65676 FMI 11: Catalytic Converter B Efficiency Root Cause Unknown

SPN 65677 or 65678

SPN Descriptors

SPN 65677 FMI 11: Catalytic Converter A Exotherm Root Cause Unknown

SPN 65678 FMI 11: Catalytic Converter B Exotherm Root Cause Unknown

SPN 65690

SPN Descriptors

SPN 65690 FMI 3: Variable Governor Control Voltage Above Normal or Shorted High

SPN 65690 FMI 4: Variable Governor Control Voltage Below Normal or Shorted Low

SPN 65701 or 65702

SPN Descriptors

SPN 65701 FMI 31: General Warning Sensor 1 Not Available

SPN 65702 FMI 31: General Warning Sensor 2 Not Available

SPN 65710

SPN Descriptors

SPN 65710 FMI 31: Emergency Stop Warning Not Available

SPN 65723

SPN Descriptors

SPN 65723 FMI 2: Camshaft Position (CMP) Sensor Circuit Data Erratic, Intermittent or Incorrect

SPN 65723 FMI 7: Camshaft Position (CMP) Sensor Mechanical System Not Responding or Out of Adjustment

SPN 65723 FMI 8: Camshaft Position (CMP) Sensor Signal Abnormal Frequency or Pulse Width

SPN 66001

SPN Descriptors

SPN 66001 FMI 3: Starter Relay Low Side Driver Voltage Above Normal or Shorted High

SPN 66001 FMI 5: Starter Relay Low Side Driver Current Below Normal or Open Circuit

SPN 66002

SPN Descriptors

SPN 66002 FMI 4: Starter Relay High Side Driver Voltage Below Normal or Shorted Low

SPN 66002 FMI 5: Starter Relay High Side Driver Current Below Normal or Open Circuit

SPN 66003

SPN Descriptors

SPN 66003 FMI 3: Malfunction Indicator Lamp (MIL) Driver Voltage Above Normal or Shorted High

SPN 66003 FMI 5: Malfunction Indicator Lamp (MIL) Driver Current Below Normal or Open Circuit

SPN 66004

SPN Descriptors

SPN 66004 FMI 3: Service Vehicle Soon Lamp (SVS) Voltage Above Normal or Shorted High

SPN 66004 FMI 5: Service Vehicle Soon Lamp (SVS) Current Below Normal or Open Circuit

SPN 66005

SPN Descriptors

SPN 66005 FMI 3: Governor Status Lamp (GSL) Voltage Above Normal or Shorted High

SPN 66005 FMI 5: Governor Status Lamp (GSL) Current Below Normal or Open Circuit

SPN 66006

SPN Descriptors

SPN 66006 FMI 3: DTC Lamp 3 Voltage Above Normal or Shorted High

SPN 66006 FMI 5: DTC Lamp 3 Current Below Normal or Open Circuit

SPN 66007

SPN Descriptors

SPN 66007 FMI 3: Buzzer Driver Short Voltage Above Normal or Shorted High

SPN 66007 FMI 5: Buzzer Driver Current Below Normal or Open Circuit

SPN 66008

SPN Descriptors

SPN 66008 FMI 3: DTC Lamp 1 Voltage Above Normal or Shorted High

SPN 66008 FMI 5: DTC Lamp 1 Current Below Normal or Open Circuit

SPN 66009

SPN Descriptors

SPN 66009 FMI 3: DTC Lamp 2 Voltage Above Normal or Shorted High

SPN 66009 FMI 5: DTC Lamp 2 Current Below Normal or Open Circuit

SPN 66010

SPN Descriptors

SPN 66010 FMI 3: Slow Mode Lamp Voltage Above Normal or Shorted High

SPN 66010 FMI 5: Slow Mode Lamp Current Below Normal or Open Circuit

SPN 66013 or 66014

SPN Descriptors

SPN 66013 FMI 3: Powertrain Relay Voltage Above Normal or Shorted High

SPN 66013 FMI 5: Powertrain Relay Current Below Normal or Open Circuit

SPN 66014 FMI 4: Powertrain Relay Contact Voltage Below Normal or Shorted Low

SPN 66017

SPN Descriptors

SPN 66017 FMI 4: Fuel Pump Relay 1 Voltage Below Normal or Shorted Low

SPN 66017 FMI 5: Fuel Pump Relay 1 Current Below Normal or Open Circuit

SPN 66018

SPN Descriptors

SPN 66018 FMI 3: Tachometer Voltage Above Normal or Shorted High

SPN 66018 FMI 5: Tachometer Current Below Normal or Open Circuit

SPN 66019 or 66020

SPN Descriptors

SPN 66019 FMI 3: Oxygen Sensor Bank A Sensor 1 Heater Voltage Above Normal or Shorted High

SPN 66019 FMI 5: Oxygen Sensor Bank A Sensor 1 Heater Current Below Normal or Open Circuit

SPN 66019 FMI 8: Oxygen Sensor Bank A Sensor 1 Heater Abnormal Frequency or Pulse Width

SPN 66020 FMI 3: Oxygen Sensor Bank B Sensor 1 Heater Voltage Above Normal or Shorted High

SPN 66020 FMI 5: Oxygen Sensor Bank B Sensor 1 Heater Current Below Normal or Open Circuit

SPN 66020 FMI 8: Oxygen Sensor Bank B Sensor 1 Heater Abnormal Frequency or Pulse Width

SPN 66021 or 66022

SPN Descriptors

SPN 66021 FMI 3: Oxygen Sensor Bank A Sensor 2 Heater Voltage Above Normal or Shorted High

SPN 66021 FMI 5: Oxygen Sensor Bank A Sensor 2 Heater Current Below Normal or Open Circuit

SPN 66021 FMI 8: Oxygen Sensor Bank A Sensor 2 Heater Abnormal Frequency or Pulse Width

SPN 66022 FMI 3: Oxygen Sensor Bank B Sensor 2 Heater Voltage Above Normal or Shorted High

SPN 66022 FMI 5: Oxygen Sensor Bank B Sensor 2 Heater Current Below Normal or Open Circuit

SPN 66022 FMI 8: Oxygen Sensor Bank B Sensor 2 Heater Abnormal Frequency or Pulse Width

SPN 66025

SPN Descriptors

SPN 66025 FMI 4: Fuel Pump Relay 2 Voltage Below Normal or Shorted Low

SPN 66025 FMI 5: Fuel Pump Relay 2 Current Below Normal or Open Circuit

SPN 66030

SPN Descriptors

SPN 66030 FMI 3: Intercooler Relay Voltage Above Normal or Shorted High

SPN 66030 FMI 5: Intercooler Relay Voltage Below Normal or Shorted Low

SPN 66035

SPN Descriptors

SPN 66035 FMI 0: Supercharger Boost Control Solenoid Data Valid but Above Normal

SPN 66035 FMI 3: Supercharger Boost Control Solenoid Data Valid but Below Normal

SPN 66035 FMI 5: Supercharger Boost Control Solenoid Current Below Normal or Open Circuit

SPN 66035 FMI 7: Supercharger Boost Control Solenoid Mechanical System Not Responding or Out of Adjustment

SPN 66040-66043

SPN Descriptors

SPN 66040 FMI 3: OEM Output Driver 1 Voltage Above Normal or Shorted High

SPN 66040 FMI 5: OEM Output Driver 1 Current Below Normal or Open Circuit

SPN 66041 FMI 3: OEM Output Driver 2 Voltage Above Normal or Shorted High

SPN 66041 FMI 5: OEM Output Driver 2 Current Below Normal or Open Circuit

SPN 66042 FMI 3: OEM Output Driver 3 Voltage Above Normal or Shorted High

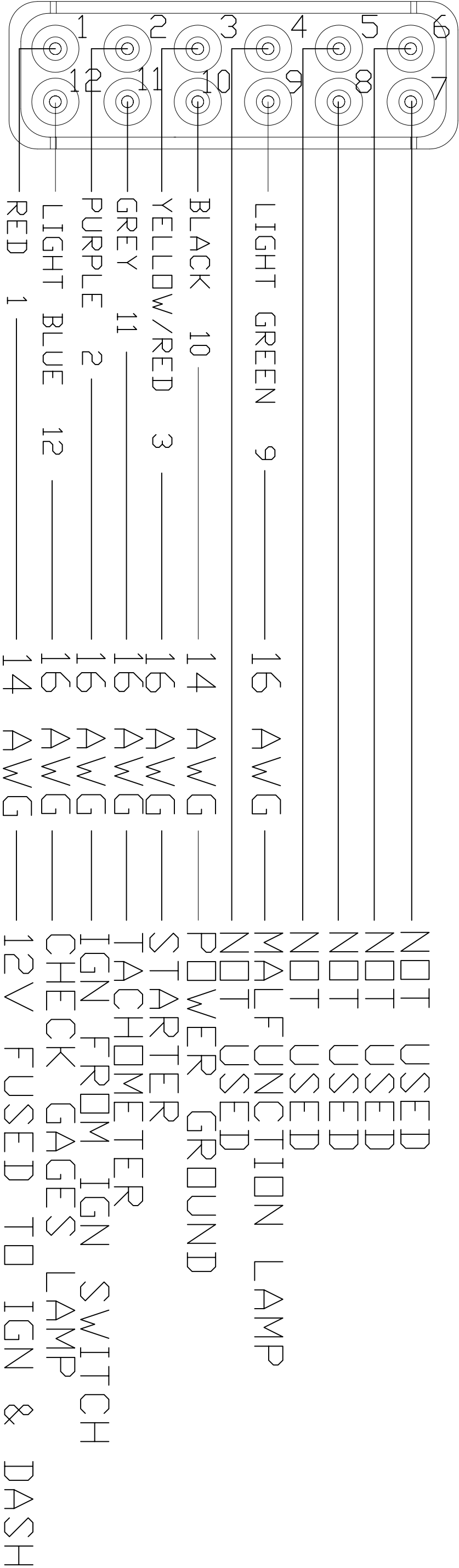
SPN 66042 FMI 5: OEM Output Driver 3 Current Below Normal or Open Circuit

SPN 66043 FMI 3: OEM Output Driver 4 Voltage Above Normal or Shorted High

SPN 66043 FMI 5: OEM Output Driver 4 Current Below Normal or Open Circuit

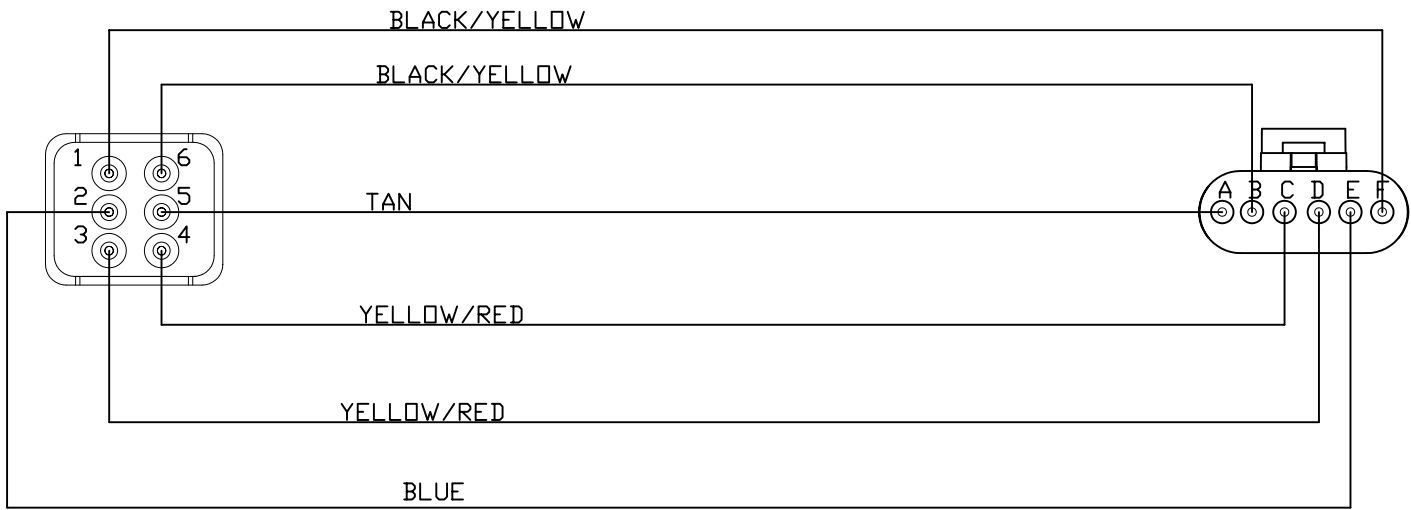
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CUSTOMER INTERFACE HARNESS



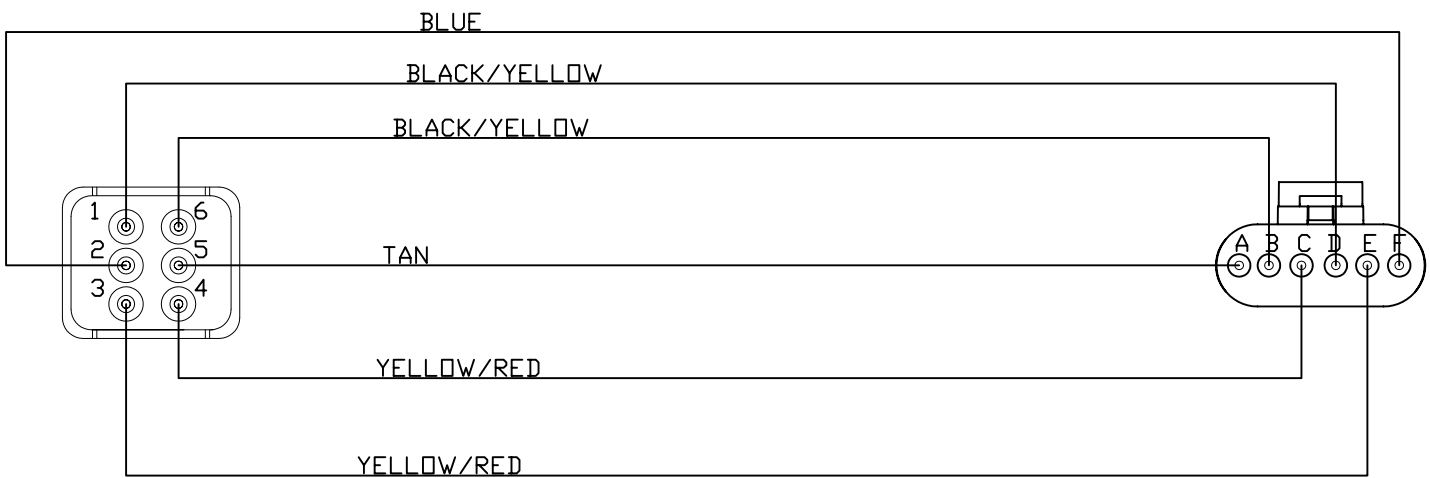
Rev .:				
TOLERANCES				
XXX = ±.010		X/X = ±1/32		
XX = ±.03		ANGLE = ±1 DEG.		
X = ±.1				
MAT'L		Equipment, Inc.		
AS NOTED		Customer Interface Harness MEFI 5		
DRWN	SF	SCALE	SIZE	REV
APPD	DATE	1/12/09	C	PC 8340
				.

PC8121



TOLERANCES		XXX = ±.010 XX = ±.020 X = ±.1	X/X = ±1/32 ANGLE = ±1 DEG.	KEM Equipment, Inc.	
MATERIAL		BY PART		TITLE	
DRAWN Joe T		SCALE 1/1		PEDAL EXTENSION TELEFLEX	
APPRO		DATE 5/17/07		SIZE C	PC 8121
					REV .

PC8119



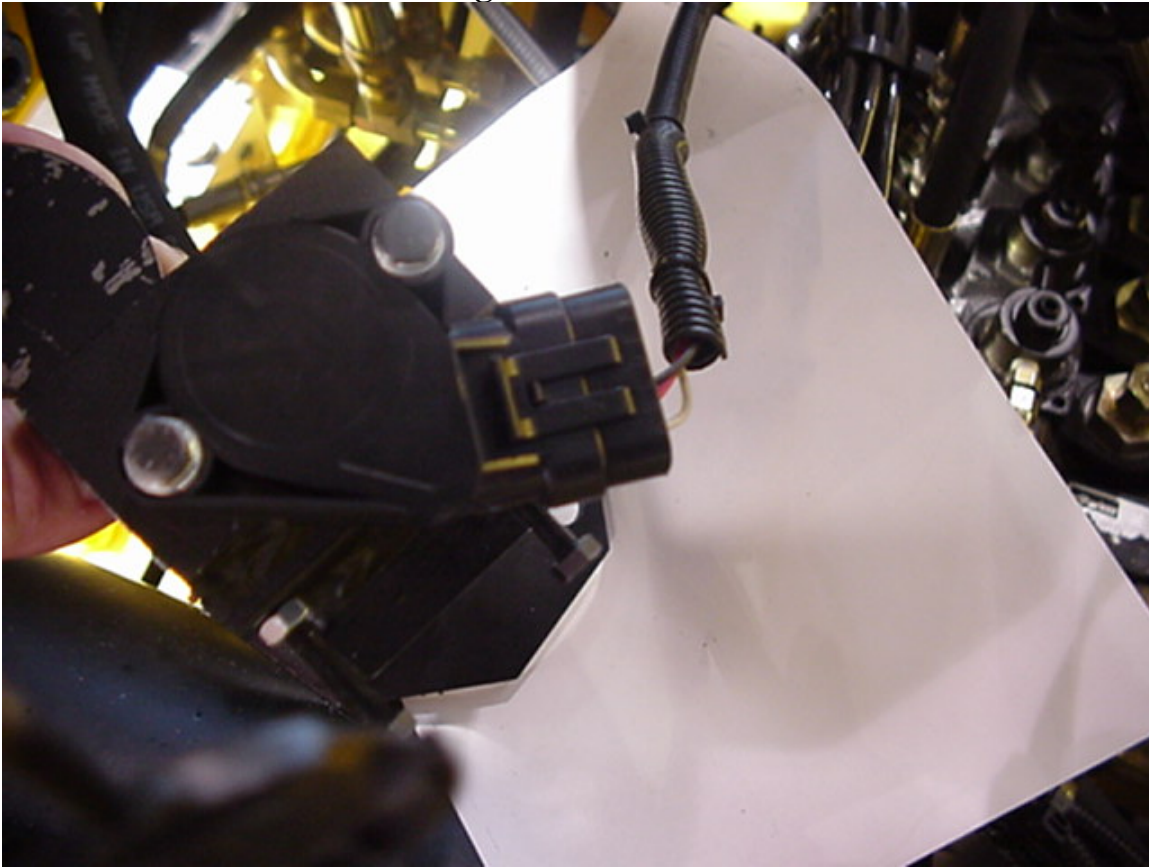
TOLERANCES		XXX = ±.010 XX = ±.020 X = ±.1	X/X = ±1/32 ANGLE = ±1 DEG.	KEM Equipment, Inc.	
MATERIAL		BY PART		TITLE	
DRAWN Joe T		SCALE 1/1		PEDAL EXTENSION WILLIAMS	
APPRO		DATE 5/17/07		SIZE C	PC 8119
					REV .

Drive-By-Wire Setup

It is important that the foot pedal accelerator potentiometer set screw stops be in place and adjusted correctly. There are two set screws, minimum/maximum idle set screw and maximum RPM range set screw. This it is important that minimum/maximum idle voltage be @ 1/2volt DC minimum to 1volt DC maximum, anything less will result in an engine stalling condition.

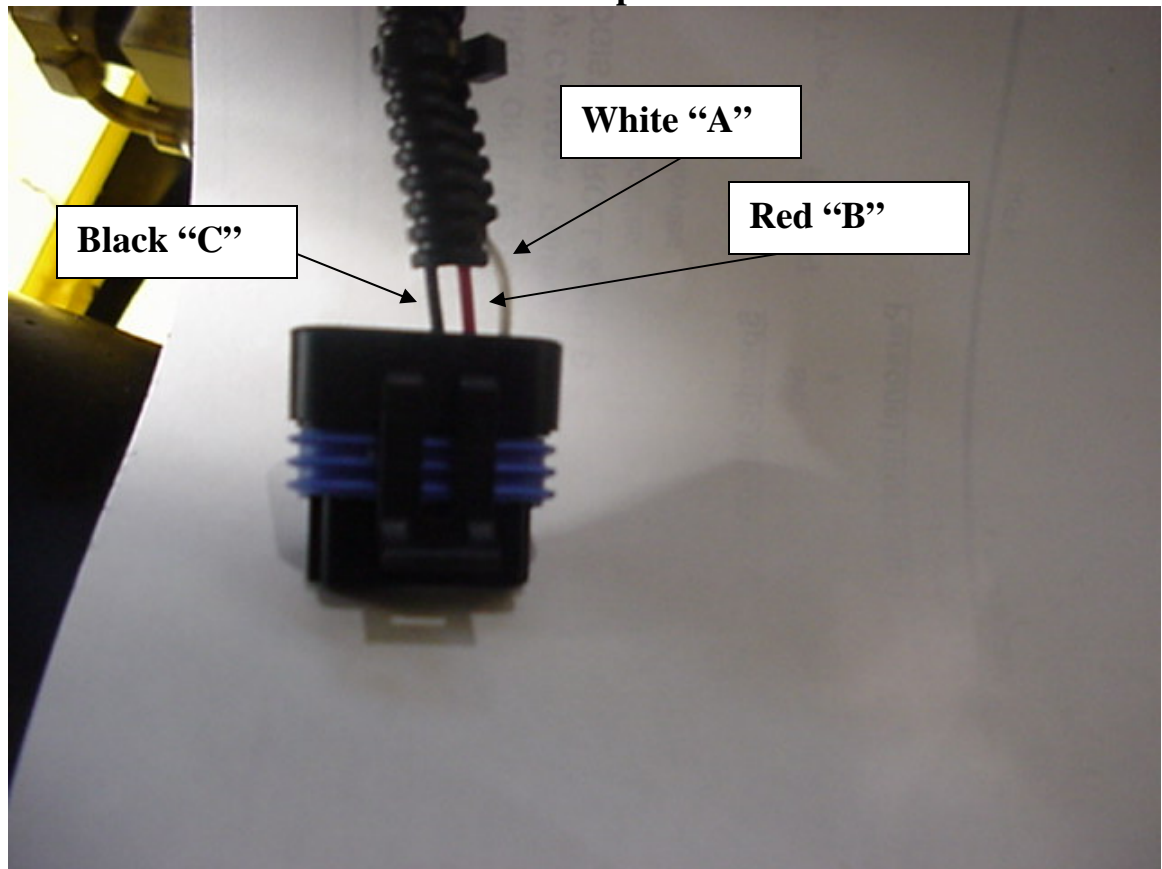
To set the idle:

- Turn the key switch to the on position.
- Select the DC range on the volt meter.

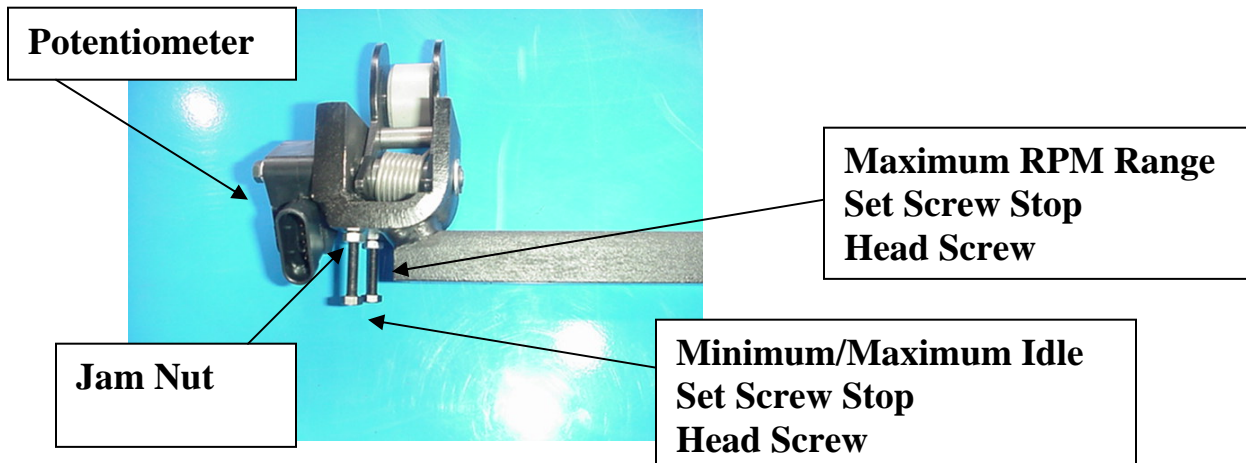


- Attach the positive lead from the volt meter to the lead wire White "A" of connector to the potentiometer.

- Attach the negative lead from the volt meter to the wire to the Red “B” of connector to the potentiometer.



- Using a wrench loosen the jam nut on the minimum/maximum idle.
- Adjust the 1/4-28 screw to $\frac{1}{2}$ volt DC \pm $\frac{1}{10}$ of a volt DC is measured on the volt meter.
- Lock the 1/4-28 Jam Nut NOTE: To prevent the screws from coming loose apply loctite to the threads.



The Maximum RPM voltage must also be set not to exceed 4.75 volts DC. This will also result in an engine stalling condition.

GM 5.7L Spark Plug Wire Routing and Spark Plug Gap

It is important when installing replacement spark plug wires that they are routed properly and secured as shown below. Heat from the exhaust manifold may burn thru the protective shield grounding the cable and causing the engine to misfire.



Right Side



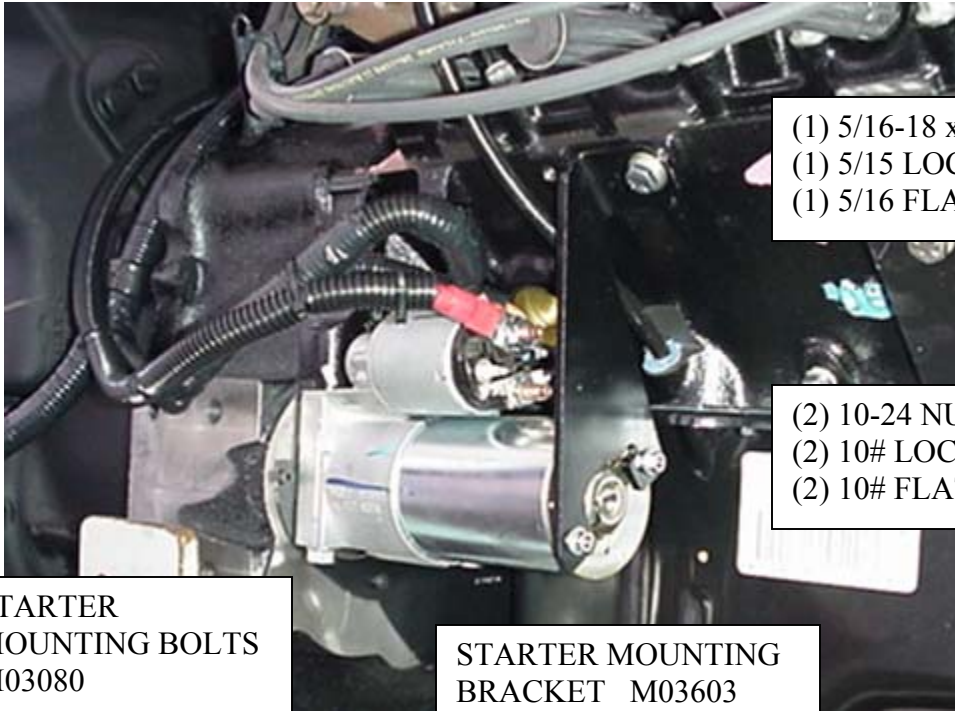
Left Side

Shown Above Part# M01442 Spark Plug Wire Set with Heat Shield

NOTE: Spark Plug Gap is set to .030

Always use Hoist approved parts to ensure proper performance.

GM 5.7 Starter Support Bracket



(1) 5/16-18 x 3/4 H.H.C.S F00259
(1) 5/16 LOCK WASHER F00214
(1) 5/16 FLAT WASHER F00235

(2) 10-24 NUTS F00714
(2) 10# LOCK WASHERS F00448
(2) 10# FLAT WASHERS

STARTER
MOUNTING BOLTS
M03080

STARTER MOUNTING
BRACKET M03603

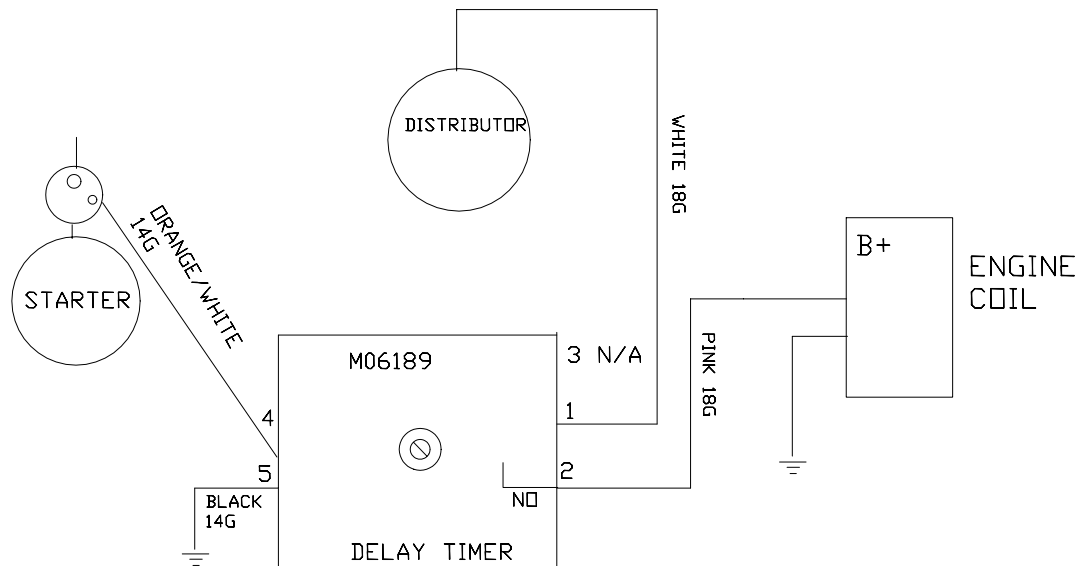
NOTE:IT IS VERY IMPORTANT THAT THE STARTER MOUNT BRACKET ITEM M03603 BE INSTALLED EVERYTIME THE STARTER IS REMOVED TO PREVENT DAMAGE TO THE ENGINE BLOCK, STARTER AND BOLTS.

The starter mounting bracket item M03603 is mounted to the back of the starter using (2) 10-24 nuts, (2) 10# lock washers, (2) 10# flat washers and to the engine block using (1) 5/16-18 x 3/4 H.H.C.S, (1) 5/16 lock washer (1) 5/16 flat washer.

Maintenance Reset Switch F Series Trucks



Maintenance Reset Switch.
Located under the console cover
on the right side next to the fuse
box.



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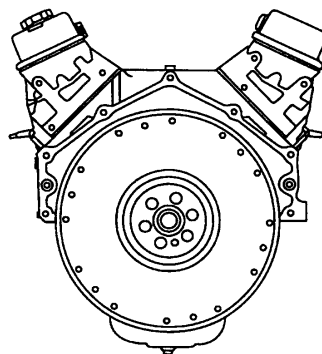
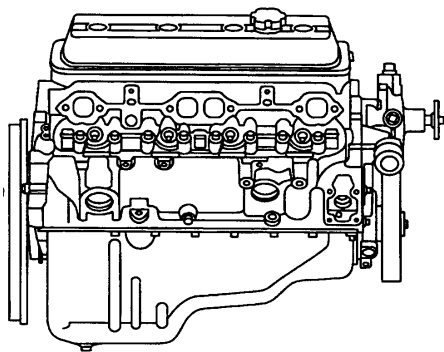
LPG Tank

WARNING: LPG is highly flammable and can cause an explosion. Do NOT disconnect the LPG tank if within 25 feet of an ignition source i.e. Electrical equipment, open flame or motor vehicles

WARNING: When removing the LPG Tank always turn the valve off on the tank and run the engine until it dies. This will remove all residual pressure in the fuel system before disconnecting the tank. If the engine will not run, close the valve on the LPG tank and slowly loosen the fitting on the tank. Take care as the fuel escapes it will cool the fitting, use a cloth or glove when doing this to protect your hands from the fitting.

1. Read the above Warning statements.
2. Close the valve on the LPG Tank
3. Allow the truck to run until it stops.
4. Loosen the fitting slowly on the LPG tank valve. Protect your hands from the cold fitting with a cloth or gloves.
5. Once all residual pressure has dissipated, remove the fitting.
6. Remove the tank from the truck and store with the other LPG Tanks in a safe location.

Industrial/Marine 5.7L Unit Repair Manual



Engine Mechanical - 5.0L, 5.7L

Specifications

SIE-ID - 348754

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Bolt and Nut	12 N.m	106 lb in
Air Conditioning (A/C) Compressor Mounting Bolt	50 N.m	37 lb ft
Belt Idler Pulley Bolt	50 N.m	37 lb ft
Camshaft Retainer Bolt	12 N.m	106 lb in
Camshaft Sprocket Bolt	25 N.m	18 lb ft
Connecting Rod Nut		
First Pass	27 N.m	20 lb ft
Final Pass	55 degrees	
Crankshaft Balancer Bolt	95 N.m	70 lb ft
Crankshaft Bearing Cap Bolt and Stud (Preferred Method)		
First Pass (Two Bolt Type Bearing Cap)	20 N.m	15 lb ft
Final Pass (Two Bolt Type Bearing Cap)	73 degrees	
First Pass (Four Bolt Type Bearing Cap)	20 N.m	15 lb ft
Final Pass Outboard Bolt (Four Bolt Type Bearing Cap)	43 degrees	
Final Pass Inboard Bolt and Stud (Four Bolt Type Bearing Cap)	73 degrees	
Crankshaft Bearing Cap Bolt and Stud (Optional Strategy)		
Two Bolt Type Bearing Cap	105 N.m	77 lb ft
Inboard Bolt and Stud (Four Bolt Type Bearing Cap)	105 N.m	77 lb ft
Outboard Bolt (Four Bolt Type Bearing Cap)	90 N.m	66 lb ft
Crankshaft Oil Deflector Nut	40 N.m	29 lb ft
Crankshaft Position Sensor Bolt	9 N.m	80 lb in
Crankshaft Pulley Bolt	58 N.m	43 lb ft
Crankshaft Rear Oil Seal Housing Nut and Bolt	12 N.m	106 lb in
Crankshaft Rear Oil Seal Housing Retainer Stud	6 N.m	53 lb in
Cylinder Head Bolt (Preferred Method)		
All Bolts First Pass in Sequence	30 N.m	22 lb ft
Long Bolt Final Pass in Sequence	75 degrees	
Medium Bolt Final Pass in Sequence	65 degrees	
Short Bolt Final Pass in Sequence	55 degrees	
Cylinder Head Bolt (Optional On-Vehicle Strategy)		
First Pass in Sequence	35 N.m	26 lb ft
Second Pass in Sequence	60 N.m	44 lb ft
Final Pass in Sequence	90 N.m	66 lb ft
Cylinder Head Core Hole Plug	20 N.m	15 lb ft
Distributor Cap Bolt	2.4 N.m	21 lb in
Distributor Clamp Bolt	25 N.m	18 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
EGR Valve Bolt		
First Pass	10 N.m	88 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Final Pass	30 N.m	22 lb ft
EGR Valve Pipe Nut at Intake Manifold	25 N.m	18 lb ft
EGR Valve Pipe Nut at Exhaust Manifold	30 N.m	22 lb ft
EGR Valve Pipe Clamp Bracket Bolt	25 N.m	18 lb ft
Engine Block Coolant Drain Hole Plug	20 N.m	15 lb ft
Engine Block Oil Gallery Plug	20 N.m	15 lb ft
Engine Coolant Temperature (ECT) Gauge Sensor	20 N.m	15 lb ft
Engine Flywheel Bolt	100 N.m	74 lb ft
Engine Front Cover Bolt	12 N.m	106 lb in
Engine Lift Bracket Bolt (Special Tool J 41427)	15 N.m	11 lb ft
Engine Lift Front Bracket Stud	35 N.m	27 lb ft
Engine Mount Bracket Bolt	51 N.m	38 lb ft
Engine Mount Through-bolt	68 N.m	50 lb ft
Engine Oil Pressure Gauge Sensor	30 N.m	22 lb ft
Engine Oil Pressure Gauge Sensor Fitting (Plus Required Angle)	15 N.m	11 lb ft
Engine Wiring Harness Bracket Nut	12 N.m	106 lb in
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	10 N.m	88 lb in
Exhaust Manifold Bolt		
First Pass	15 N.m	11 lb ft
Final Pass	30 N.m	22 lb ft
Fan and Water Pump Pulley Bolt	25 N.m	18 lb ft
Fuel Pipe Bracket Bolt	6 N.m	53 lb in
Fuel Pipe Retainer Nut	3 N.m	27 lb in
Generator and Drive Belt Tensioner Bracket Bolt and Nut to Engine	41 N.m	30 lb ft
Generator and Drive Belt Tensioner Bracket Stud to Engine	20 N.m	15 lb ft
Generator Mounting Bolt	50 N.m	37 lb ft
Generator Mounting Rear Bracket Bolt to Generator and Drive Belt Tensioner Bracket	50 N.m	37 lb ft
Ignition Coil Stud	12 N.m	106 lb in
Knock Sensor	20 N.m	15 lb ft
Lower Intake Manifold Bolt		
First Pass in Sequence	3 N.m	27 lb in
Second Pass in Sequence	12 N.m	106 lb in
Final Pass in Sequence	15 N.m	11 lb ft
Oil Filter	37 N.m	27 lb ft
Oil Filter Adapter Bolt	25 N.m	18 lb ft
Oil Filter Fitting	35 N.m	26 lb ft
Oil Level Indicator Tube Bolt	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan Stud (Front)	6 N.m	53 lb in
Oil Pan Stud Nut	25 N.m	18 lb ft
Oil Pan Bolt or Stud Bolt	12 N.m	106 lb in
Oil Pump Bolt to Rear Crankshaft Bearing Cap	90 N.m	66 lb ft
Oil Pump Cover Bolt	12 N.m	106 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Power Steering Pump Bracket Bolt to Engine	41 N.m	30 lb ft
Power Steering Pump Bracket Stud to Engine	20 N.m	15 lb ft
Power Steering Pump Bracket Stud Nut	41 N.m	30 lb ft
Power Steering Pump Bolt	50 N.m	37 lb ft
Power Steering Pump Nut to Engine	41 N.m	30 lb ft
Power Steering Pump Rear Bracket Nut	50 N.m	37 lb ft
Spark Plug		
Initial Installation (New Cylinder Head)	30 N.m	22 lb ft
All Subsequent Installations	15 N.m	11 lb ft
Spark Plug Wire Support Bolt	12 N.m	106 lb in
Square Socket Plug (Engine Block Oil Gallery)	20 N.m	15 lb ft
Starter Motor Bolt	40 N.m	29 lb ft
Transmission Cover Bolt	12 N.m	106 lb in
Upper Intake Manifold Stud		
First Pass	5 N.m	44 lb in
Final Pass	10 N.m	88 lb in
Valve Lifter Guide Retainer Bolt	25 N.m	18 lb ft
Valve Rocker Arm Cover Bolt	12 N.m	106 lb in
Water Outlet Stud	25 N.m	18 lb ft
Water Pump Bolt	45 N.m	33 lb ft

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Engine Mechanical Specifications (L30 (VIN M))

Application	Specification	
	Metric	English
General Data		
Engine Type	V8	
Displacement	5.0L	305 CID
RPO (VIN Code)	L30 (M)	
Bore	94.89 mm	3.736 in
Stroke	88.39 mm	3.480 in
Compression Ratio	9.4:1	
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Gap	1.52 mm	0.060 in
Oil Pressure (Minimum Hot)	41.4 kpa at 1,000 RPM	6.0 psig at 1,000 RPM
Oil Pressure (Minimum Hot)	124.1 kpa at 2,000 RPM	18.0 psig at 2,000 RPM
Oil Pressure (Minimum Hot)	165.5 kpa at 4,000 RPM	24.0 psig at 4,000 RPM
Camshaft		
End Play	0.11-0.30 mm	0.004-0.012 in
Journal Diameter	47.440-47.490 mm	1.8677-1.8697 in
Lobe Lift (Exhaust)	7.20-7.30 mm	0.283-0.287 in
Lobe Lift (Intake)	6.97-7.07 mm	0.274-0.278 in
Connecting Rod		

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Engine Mechanical Specifications (L30 (VIN M)) (cont'd)

Application	Specification	
	Metric	English
Connecting Rod Bearing Clearance (Production)	0.033–0.078 mm	0.0013–0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025–0.063 mm	0.0010–0.0025 in
Connecting Rod Journal Diameter	53.304–53.334 mm	2.0986–2.0998 in
Connecting Rod Journal Taper (Production)	0.007 mm Maximum	0.0003 in Maximum
Connecting Rod Journal Taper (Service)	0.025 mm Maximum	0.0010 in Maximum
Connecting Rod Journal Out-of-Round (Production)	0.007 mm Maximum	0.0003 in Maximum
Connecting Rod Journal Out-of-Round (Service)	0.025 mm Maximum	0.0010 in Maximum
Connecting Rod Side Clearance	0.15–0.68 mm	0.006–0.027 in
Crankshaft		
Crankshaft Bearing Clearance #1 (Production)	0.018–0.053 mm	0.0007–0.0021 in
Crankshaft Bearing Clearance #2, #3, and #4 (Production)	0.030–0.068 mm	0.0012–0.0027 in
Crankshaft Bearing Clearance #5 (Production)	0.020–0.060 mm	0.0008–0.0024 in
Crankshaft Bearing Clearance #1 (Service)	0.025–0.051 mm	0.0010–0.0020 in
Crankshaft Bearing Clearance #2, #3, and #4 (Service)	0.025–0.064 mm	0.0010–0.0025 in
Crankshaft Bearing Clearance Service #5	0.038–0.063 mm	0.0015–0.0025 in
Crankshaft End Play	0.05–0.20 mm	0.002–0.008 in
Crankshaft Journal Diameter #1	62.189–62.212 mm	2.4484–2.4493 in
Crankshaft Journal Diameter #2, #3, and #4	62.181–62.207 mm	2.4481–2.4491 in
Crankshaft Journal Diameter #5	62.181–62.212 mm	2.4481–2.4493 in
Crankshaft Journal Taper (Production)	0.005 mm Maximum	0.0002 in Maximum
Crankshaft Journal Out-of-Round (Production)	0.005 mm Maximum	0.0002 in Maximum
Crankshaft Runout at Rear Flange	0.038 mm	0.0015 in
Cylinder Bore		
Diameter	94.876–94.929 mm	3.7353–3.7374 in
Out-of-Round (Production)	0.025 mm	0.001 in
Out-of-Round (Service)	0.05 mm	0.002 in
Taper (Production—Relief Side)	0.025 mm	0.0010 in
Taper (Production—Thrust Side)	0.012 mm	0.0005 in
Service Limit	0.025 mm	0.0010 in
Cylinder Head		
Surface Flatness (Engine Block Deck)	0.10 mm	0.004 in
Surface Flatness (Exhaust Manifold Deck)	0.05 mm	0.002 in
Surface Flatness (Intake Manifold Deck)	0.10 mm	0.004 in
Piston		
Piston Bore Clearance (Production)	0.018–0.053 mm	0.0007–0.002 in
Piston Bore Clearance (Service)	0.018–0.068 mm	0.0007–0.0026 in
Piston Pin		
Clearance in Piston (Production)	0.010–0.020 mm	0.0004–0.0008 in
Clearance in Piston (Service)	0.013–0.025 mm	0.0005–0.0010 in
Diameter	23.545–23.548 mm	0.9270–0.9271 in
Interference Fit in Connecting Rod	0.021–0.040 mm	0.0008–0.0016 in
Piston Rings (End Gaps Measured in Cylinder Bore)		
Piston Compression Ring Groove Clearance (Production—Top Groove)	0.030–0.070 mm	0.0012–0.0027 in

Engine Mechanical Specifications (L30 (VIN M)) (cont'd)

Application	Specification	
	Metric	English
Piston Compression Ring Groove Clearance (Production—2nd Groove)	0.040–0.080 mm	0.0015–0.003 in
Piston Compression Ring Groove Clearance (Service Limit—Top Groove)	0.030–0.090 mm	0.0012–0.0035 in
Piston Compression Ring Groove Clearance (Service Limit—2nd Groove)	0.040–0.100 mm	0.0015–0.0040 in
Piston Compression Ring Gap (Production—Top Groove)	0.25–0.51 mm	0.010–0.020 in
Piston Compression Ring Gap (Production—2nd Groove)	0.46–0.66 mm	0.018–0.026 in
Piston Compression Ring Gap (Service—Top Groove)	0.25–0.65 mm	0.010–0.025 in
Piston Compression Ring Gap (Service—2nd Groove)	0.46–0.90 mm	0.018–0.035 in
Piston Oil Ring Groove Clearance (Production)	0.051–0.17 mm	0.002–0.006 in
Piston Oil Ring Groove Clearance (Service)	0.051–0.22 mm	0.002–0.009 in
Piston Oil Ring Gap (Production)	0.25–0.76 mm	0.010–0.030 in
Piston Oil Ring Gap (Service)	0.25–0.89 mm	0.010–0.035 in
Valve System		
Valve Lifter	Hydraulic Roller	
Valve Rocker Arm Ratio	1.5:1	
Valve Lash	Rotate the Valve Rocker Arm Nut Clockwise 360 degrees (1 Turn) from Zero Lash	
Valve Face Angle	—	45 degrees
Valve Seat Angle	—	46 degrees
Valve Seat Runout	0.05 mm Maximum	0.002 in Maximum
Valve Seat Width (Exhaust)	1.65–2.49 mm	0.065–0.098 in
Valve Seat Width (Intake)	1.14–1.78 mm	0.045–0.070 in
Valve Spring Free Length	51.3 mm	2.02 in
Valve Spring Installed Height (Exhaust)	42.92–43.43 mm	1.67–1.70 in
Valve Spring Installed Height (Intake)	42.92–43.43 mm	1.67–1.70 in
Valve Spring Pressure (Closed)	338–374 N at 43.2	76–84 lb at 1.70
Valve Spring Pressure (Open)	832–903 N at 32.3	187–203 lb at 1.27
Valve Stem Clearance Exhaust (Production)	0.025–0.069 mm	0.0010–0.0027 in
Valve Stem Clearance Intake (Production)	0.025–0.069 mm	0.0010–0.0027 in
Valve Stem Clearance Exhaust (Service)	0.025–0.094 mm	0.0010–0.0037 in
Valve Stem Clearance Intake (Service)	0.025–0.094 mm	0.0010–0.0037 in

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Engine Mechanical Specifications (L31 (VIN R))

Application	Specification	
	Metric	English
General Data		
Engine Type	V8	
Displacement	5.7L	350 CID
RPO (VIN Code)	L31 (R)	
Bore	101.63 mm	4.0012 in
Stroke	88.39 mm	3.480 in

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Engine Mechanical Specifications (L31 (VIN R)) (cont'd)

Application	Specification	
	Metric	English
Compression Ratio	9.4:1	
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Gap	1.52 mm	0.060 in
Oil Pressure (Minimum Hot)	41.4 kpa at 1,000 RPM	6.0 psig at 1,000 RPM
Oil Pressure (Minimum Hot)	124.1 kpa at 2,000 RPM	18.0 psig at 2,000 RPM
Oil Pressure (Minimum Hot)	165.5 kpa at 4,000 RPM	24.0 psig at 4,000 RPM
Camshaft		
End Play	0.11–0.30 mm	0.004–0.012 in
Journal Diameter	47.440–47.490 mm	1.8677–1.8697 in
Lobe Lift (Exhaust)	7.20–7.30 mm	0.283–0.287 in
Lobe Lift (Intake)	6.97–7.07 mm	0.274–0.278 in
Connecting Rod		
Connecting Rod Bearing Clearance (Production)	0.033–0.078 mm	0.0013–0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025–0.063 mm	0.0010–0.0025 in
Connecting Rod Journal Diameter	53.304–53.334 mm	2.0986–2.0998 in
Connecting Rod Journal Taper (Production)	0.007 mm Maximum	0.0003 in Maximum
Connecting Rod Journal Taper (Service)	0.025 mm Maximum	0.0010 in Maximum
Connecting Rod Journal Out-of-Round (Production)	0.007 mm Maximum	0.0003 in Maximum
Connecting Rod Journal Out-of-Round (Service)	0.025 mm Maximum	0.0010 in Maximum
Connecting Rod Side Clearance	0.15–0.68 mm	0.006–0.027 in
Crankshaft		
Crankshaft Bearing Clearance #1 (Production)	0.018–0.053 mm	0.0007–0.0021 in
Crankshaft Bearing Clearance #2, #3, and #4 (Production)	0.030–0.068 mm	0.0012–0.0027 in
Crankshaft Bearing Clearance #5 (Production)	0.020–0.060 mm	0.0008–0.0024 in
Crankshaft Bearing Clearance #1 (Service)	0.025–0.051 mm	0.0010–0.0020 in
Crankshaft Bearing Clearance #2, #3, and #4 (Service)	0.025–0.064 mm	0.0010–0.0025 in
Crankshaft Bearing Clearance Service #5	0.038–0.063 mm	0.0015–0.0025 in
Crankshaft End Play	0.05–0.20 mm	0.002–0.008 in
Crankshaft Journal Diameter #1	62.189–62.212 mm	2.4484–2.4493 in
Crankshaft Journal Diameter #2, #3, and #4	62.181–62.207 mm	2.4481–2.4491 in
Crankshaft Journal Diameter #5	62.181–62.212 mm	2.4481–2.4493 in
Crankshaft Journal Taper (Production)	0.005 mm Maximum	0.0002 in Maximum
Crankshaft Journal Out-of-Round (Production)	0.005 mm Maximum	0.0002 in Maximum
Crankshaft Runout at Rear Flange	0.038 mm	0.0015 in
Cylinder Bore		
Diameter	101.618–101.643 mm	4.0007–4.0017 in
Out-of-Round (Production)	0.025 mm	0.001 in
Out-of-Round (Service)	0.05 mm	0.002 in
Taper (Production—Relief Side)	0.025 mm	0.0010 in
Taper (Production—Thrust Side)	0.012 mm	0.0005 in
Service Limit	0.025 mm	0.0010 in
Cylinder Head		
Surface Flatness (Engine Block Deck)	0.10 mm	0.004 in
Surface Flatness (Exhaust Manifold Deck)	0.05 mm	0.002 in

Engine Mechanical Specifications (L31 (VIN R)) (cont'd)

Application	Specification	
	Metric	English
Surface Flatness (Intake Manifold Deck)	0.10 mm	0.004 in
Piston		
Piston Bore Clearance (Production)	0.018–0.053 mm	0.0007–0.002 in
Piston Bore Clearance (Service)	0.018–0.068 mm	0.0007–0.0026 in
Piston Pin		
Clearance in Piston (Production)	0.013–0.023 mm	0.0005–0.0009 in
Clearance in Piston (Service)	0.013–0.025 mm	0.0005–0.0010 in
Diameter	23.545–23.548 mm	0.9270–0.9271 in
Interference Fit in Connecting Rod	0.021–0.040 mm	0.0008–0.0016 in
Piston Rings (End Gaps Measured in Cylinder Bore)		
Piston Compression Ring Groove Clearance (Production—Top Groove)	0.030–0.070 mm	0.0012–0.0027 in
Piston Compression Ring Groove Clearance (Production—2nd Groove)	0.040–0.080 mm	0.0015–0.003 in
Piston Compression Ring Groove Clearance (Service Limit—Top Groove)	0.030–0.090 mm	0.0012–0.0035 in
Piston Compression Ring Groove Clearance (Service Limit—2nd Groove)	0.040–0.100 mm	0.0015–0.0040 in
Piston Compression Ring Gap (Production—Top Groove)	0.25–0.40 mm	0.0098–0.015 in
Piston Compression Ring Gap (Production—2nd Groove)	0.46–0.66 mm	0.018–0.025 in
Piston Compression Ring Gap (Service—Top Groove)	0.25–0.50 mm	0.009–0.019 in
Piston Compression Ring Gap (Service—2nd Groove)	0.46–0.80 mm	0.018–0.031 in
Piston Oil Ring Groove Clearance (Production)	0.046–0.096 mm	0.0018–0.0037 in
Piston Oil Ring Groove Clearance (Service)	0.046–0.100 mm	0.0018–0.0039 in
Piston Oil Ring Gap (Production)	0.25–0.76 mm	0.009–0.029 in
Piston Oil Ring Gap (Service)	0.25–0.90 mm	0.009–0.035 in
Valve System		
Valve Lifter	Hydraulic Roller	
Valve Rocker Arm Ratio	1.5:1	
Valve Lash	Rotate the Valve Rocker Arm Nut Clockwise 360 degrees (1 Turn) from Zero Lash	
Valve Face Angle	—	45 degrees
Valve Seat Angle	—	46 degrees
Valve Seat Runout	0.05 mm Maximum	0.002 in Maximum
Valve Seat Width (Exhaust—Heavy Duty)	1.50–2.56 mm	0.059–0.101 in
Valve Seat Width (Exhaust—Light Duty)	1.65–2.49 mm	0.065–0.098 in
Valve Seat Width (Intake)	1.02–1.65 mm	0.040–0.065 in
Valve Spring Free Length	51.3 mm	2.02 in
Valve Spring Installed Height (Exhaust)	42.92–43.43 mm	1.67–1.70 in
Valve Spring Installed Height (Intake)	42.92–43.43 mm	1.67–1.70 in
Valve Spring Pressure (Closed)	338–374 N at 43.2	76–84 lb at 1.70
Valve Spring Pressure (Open)	832–903 N at 32.3	187–203 lb at 1.27
Valve Stem Clearance Exhaust (Production)	0.025–0.069 mm	0.0010–0.0027 in
Valve Stem Clearance Intake (Production)	0.025–0.069 mm	0.0010–0.0027 in
Valve Stem Clearance Exhaust (Service)	0.025–0.094 mm	0.0010–0.0037 in

Engine Mechanical Specifications (L31 (VIN R)) (cont'd)

Application	Specification	
	Metric	English
Valve Stem Clearance Intake (Service)	0.025–0.094 mm	0.0010–0.0037 in

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GM SPO Group Numbers

Application	GM SPO Group Number
Accelerator Control Cable Bracket	3.454
Belt Idler Pulley (Grooved)	1.062
Belt Idler Pulley (Smooth)	1.062
Camshaft Bearing	0.539
Camshaft Retainer	0.529
Camshaft Sprocket	0.736
Camshaft Sprocket Locator Pin	0.738
Camshaft Timing Chain	0.724
Clutch Pilot Bearing	0.649
Connecting Rod	0.603
Connecting Rod Bearing Kit	0.616
Coolant Radiator	1.219
Crankshaft Balancer	0.659
Crankshaft Bearing Kit	0.096
Crankshaft Front Oil Seal	0.213
Crankshaft Oil Deflector	1.430
Crankshaft Rear Oil Seal	0.137
Crankshaft Rear Oil Seal Housing	0.137
Crankshaft Rear Oil Seal Housing Retainer Stud	0.137
Crankshaft Rear Oil Seal Housing Gasket	0.137
Crankshaft Rear Oil Seal Retainer Stud	0.137
Crankshaft Position Sensor	2.383
Crankshaft Position Sensor Reluctor Ring	2.383
Crankshaft Position Sensor Seal (O-ring)	2.383
Crankshaft Pulley	0.659
Crankshaft Sprocket	0.728
Cylinder Head	0.269
Cylinder Head Gasket	0.289
Distributor	2.361
Distributor Cap	2.367
Distributor Clamp	2.363
Distributor Gasket	2.363
Dowel Pin (Cylinder Head Locator)	8.939
Dowel Straight Pin (Transmission Locator)	8.939
Drive Belt Tensioner	1.060
EGR Valve	3.670
EGR Valve Gasket	3.680
EGR Valve Pipe	3.675

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
EGR Valve Pipe Fitting	3.680
Evaporative Emission Canister Purge Solenoid Valve	3.130
Evaporative Emission Canister Purge Solenoid Valve Harness	3.145
Engine Block	N.S.
Engine Block Core Hole Plug	0.034
Engine Block Oil Gallery Plug	1.531
Engine Camshaft	0.519
Engine Coolant Heater	1.152
Engine Coolant Temperature Sensor	1.150
Engine Coolant Temperature Gauge Sensor	1.150
Engine Coolant Thermostat	1.246
Engine Coolant Thermostat Seal (O-ring)	1.252
Engine Crankshaft	0.646
Engine Flywheel	0.666
Engine Front Cover	0.206
Engine Mount Bracket	0.029
Engine Mount Bracket Spacer	0.029
Engine Oil Pressure Gauge Sensor	1.800
Engine Oil Pressure Gauge Sensor Fitting	1.800
Engine Piston Kit (Piston and Piston Pin)	0.629
Engine Wiring Harness Bracket	2.559
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.270
Exhaust Valve	0.297
Expansion Cup Plug (Camshaft Rear Bearing Hole)	8.970
Fan & Water Pump & A/C Compressor & Generator & Power Steering Pump Belt	1.066
Fan & Water Pump & Generator & Power Steering Pump Belt	1.066
Fan and Water Pump Pulley	1.062
Flywheel Locator Pin	0.669
Front Groove Pin (Crankshaft Balancer)	8.940
Fuel Pipe (Included in Fuel Injection Feed and Return Pipe Kit only)	3.163
Fuel Pipe Retainer Bracket (Included in Fuel Injection Feed and Return Pipe Kit only)	3.163
Fuel Injector (O-ring) Seal Kit	3.331
Generator and Drive Belt Tensioner Bracket	1.060
Ignition Coil	2.170
Ignition Coil Wire Harness	2.240
Intake Valve	0.296
Knock Sensor	2.383
Lower Intake Manifold (Included in Lower Intake Manifold Kit only)	3.265
Lower Intake Manifold Gasket Kit	3.270
MAP Sensor	3.682
MAP Sensor Seal (O-ring)	3.682
Oil Fill Cap	1.758
Oil Filter	1.836
Oil Filter Adapter	1.840

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Oil Filter Adapter Gasket	1.840
Oil Filter Adapter Seal (O-ring)	1.844
Oil Filter Bypass Valve	1.837
Oil Filter Fitting	1.855
Oil Level Indicator	1.516
Oil Level Indicator Tube	1.516
Oil Pan Drain Plug	1.453
Oil Pan Drain Plug Seal (O-ring)	1.456
Oil Pan Gasket	1.429
Oil Pan Kit with Gasket	1.426
Oil Pan Reinforcement	1.426
Oil Pump	1.652
Oil Pump Cover	1.723
Oil Pump Drive Shaft	1.639
Oil Pump Drive Shaft Retainer	1.639
Oil Pump Pressure Relief Valve	1.609
Oil Pump Pressure Relief Valve Spring	1.609
Oil Pump Pressure Relief Valve Spring Bore Plug	1.609
Oil Pump Pressure Relief Valve Spring Straight Pin	1.609
Oil Pump Screen	1.656
PCV Tube	1.762
PCV Valve	1.745
PCV Valve Cover	1.745
PCV Valve Elbow	1.762
PCV Valve Grommet	1.745
PCV Valve Hose	1.762
Pin (Oil Pump Locator)	1.723
Piston (with Pin)	0.629
Piston Ring Kit	0.643
Power Steering Pump Bracket	6.606
Radiator Air Deflector	1.272
Radiator Fan Shroud	1.277
Radiator Outlet Hose	1.173
Radiator Surge Tank	1.240
Secondary Air Injection (AIR) Check Valve (Crossover) Pipe	3.675
Secondary Air Injection (AIR) Pipe	3.675
Spark Plug	2.270
Spark Plug Wire	2.240
Spark Plug Wire Retainer	2.251
Spark Plug Wire Shield	2.251
Spark Plug Wire Support	2.251
Spring Type S Pin (Crankshaft Rear Oil Seal Housing Locator)	8.940
Square Socket Plug (Engine Block Oil Gallery)	8.971
Starter Motor	2.041
TBI Fuel Meter	3.734

Engine**Engine Mechanical - 5.0L, 5.7L 6-11****GM SPO Group Numbers (cont'd)**

Application	GM SPO Group Number
Throttle Body	3.335
Throttle Body to Upper Manifold Gasket (Included in Service Kits only)	N.S.
Upper Intake Manifold (included in Intake Manifold Seal Kit)	3.625
Upper Intake Manifold to Lower Intake Manifold Gasket (Included in Intake Manifold Seal Kit)	3.270
Valve Lifter	0.459
Valve Lifter Guide	0.439
Valve Lifter Guide Retainer	0.439
Valve Pushrod	0.426
Valve Rocker Arm (Included in Valve Rocker Arm Kit only)	N.S.
Valve Rocker Arm Ball (Included in Valve Rocker Arm Kit only)	N.S.
Valve Rocker Arm Ball Stud	0.429
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Gasket	0.423
Valve Rocker Arm Kit (Valve Rocker Arm, Ball, Nut)	0.333
Valve Rocker Arm Nut	0.429
Valve Spring	0.303
Valve Spring Cap	0.309
Valve Stem Key	0.310
Valve Stem Oil Seal	0.308
Water Outlet	1.153
Water Pump Gasket	1.079
Water Pump Inlet Hose	1.097
Water Pump Kit (with Gaskets)	1.069
Woodruff Key (Crankshaft Balancer)	8.960

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Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Coolant Sealing Pellets	Sealant	3634621
Crankshaft Balancer Keyway	Adhesive	12346141
Cylinder Head Bolt Threads	Sealant	12346004
Engine Block Coolant Drain Hole Plug	Sealant	12346004
Engine Block to Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141
Engine Block to Engine Front Cover Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141
Engine Block at the Lower Intake Manifold Sealing Surfaces	Adhesive	12346141
Engine Block Oil Gallery Plug	Sealant	12346004
Engine Coolant Sensor Threads	Sealant	12346004
Engine Coolant Temperature (ECT) Gauge Sensor	Sealant	12346004
Engine Oil	SAE 5W-30 Oil	12345610
Engine Oil Pressure Gauge Sensor	Sealant	12346004
Engine Oil Pressure Gauge Sensor Fitting Threads	Sealant	12346004

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Sealers, Adhesives, and Lubricants (cont'd)

Application	Type of Material	GM Part Number
Engine Oil Supplement	Lubricant	1052367
Exhaust Manifold Bolt Threads	Threadlock	12345493
Expansion Cup Plug (Camshaft Rear Bearing Hole Plug)	Sealant	12346004
Expansion Cup Plug (Engine Block Core Hole)	Sealant	12346004
Knock Sensor Threads	Sealant	12346004
Lower Intake Manifold Bolt Threads	Threadlock	12345382
Oil Level Indicator Tube	Sealant	12346004
Oil Pump Screen Tube	Sealant	12346004
Valve Rocker Arm Ball Stud	Lubricant	1052271
Valve Train Component Prelube	Lubricant	12345501
Water Pump Bolt Threads	Sealant	12346004

Diagnostic Information and Procedures

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Base Engine Misfire Diagnosis

Checks	Action
<p>Engine performance diagnosis procedures are covered in Engine Controls and should be consulted for diagnosis of any Driveability, Emissions, or Malfunctioning Indicator Lamp (MIL) concerns.</p> <p>The following diagnosis covers common concerns and possible causes.</p> <p>When the proper diagnosis is made, the concern should be corrected by adjustment, repair or replacement as required.</p> <p>Refer to the appropriate section of the service manual for each specific procedure.</p> <p>This diagnostic table will assist in engine misfire diagnosis due to a mechanical concern such as a faulty engine camshaft, worn or damaged bearings or bent valve pushrod.</p> <p>This table will not isolate a crossed fuel injector wire, faulty fuel injector or any other driveability component failure that may cause a misfire.</p> <p>The Powertrain On-Board Diagnostic System checks must be performed first.</p> <p>When using this table to make a Base Engine Misfire diagnosis, begin with the preliminary information below and then proceed to the specific category.</p>	
Preliminary	<ol style="list-style-type: none"> 1. Perform DTC P0300 before proceeding with Base Engine Misfire Diagnosis information. DTC P0300 will assist in determining which cylinder or cylinders are misfiring. 2. Perform a visual inspection of the following: <ul style="list-style-type: none"> • A loose or improperly installed engine flywheel or crankshaft balancer • Worn, damaged or misaligned accessory drive system components 3. Listen to the engine for any abnormal internal engine noises. 4. Inspect the engine for acceptable oil pressure. 5. Verify if the engine has excessive oil consumption. 6. Verify if the engine has excessive coolant consumption. 7. Perform a compression test on the engine.
Intake Manifold Leaks	<p>An intake manifold that has a vacuum leak may cause a misfire.</p> <p>Inspect for the following:</p> <ul style="list-style-type: none"> • Improperly installed or damaged vacuum hoses • Faulty or improperly installed lower intake manifold and/or gaskets • Cracked or damaged lower intake manifold • Improperly installed MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged • Improperly installed throttle body or damaged gasket • Warped intake manifold • Warped or damaged cylinder head sealing surface
Coolant Consumption	<p>Coolant consumption may or may not cause the engine to overheat.</p> <p>Inspect for the following:</p> <ul style="list-style-type: none"> • External coolant leaks • Faulty cylinder head gasket • Warped cylinder head • Cracked cylinder head • Damaged engine block

Base Engine Misfire Diagnosis (cont'd)

Checks	Action
Oil Consumption	<p>Oil consumption may or may not cause the engine to misfire.</p> <ol style="list-style-type: none"> 1. Remove the spark plugs and inspect for an oil fouled spark plug. 2. Perform a cylinder compression test. 3. If the compression test indicates worn valves or valve guides, inspect the following: <ul style="list-style-type: none"> • Worn, brittle, or improperly installed valve stem oil seals • Worn valve guides • Worn valve stems • Worn or burnt valves or valve seats 4. If the compression test indicates worn or damaged piston rings, inspect the following: <ul style="list-style-type: none"> • Broken or improperly seated piston rings • Excessive piston ring end gap • Excessive cylinder bore wear or taper • Cylinder damage • Piston damage
Abnormal Internal Engine Noises	<ol style="list-style-type: none"> 1. Start the engine and determine if the noise is timed to the engine camshaft speed or the crankshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft speed and one knock per flash is the engine camshaft speed. 3. If the noise is timed to the engine camshaft speed, inspect the following: <ul style="list-style-type: none"> • Missing or loose valve train components • Worn or loose valve rocker arms • Worn or bent valve pushrods • Faulty valve springs • Bent or burnt valves • Worn engine camshaft lobes • Worn or damaged camshaft timing chain and/or sprockets <p>Important: A slight COLD knock or piston slapping noise could be considered normal if not present after the engine has reached normal operating temperatures.</p> 4. If the knock is timed to the crankshaft speed, inspect the following: <ul style="list-style-type: none"> • Worn crankshaft or connecting rod bearings • Piston or cylinder damage • Worn piston or piston pin • Faulty connecting rod • Excessive carbon build-up on the top of the piston
No Abnormal Internal Engine Noise	<ol style="list-style-type: none"> 1. Inspect for a worn or improperly installed camshaft timing chain and/or sprockets. 2. Remove the valve rocker arm cover on the side of the engine with the cylinder that is misfiring. 3. Inspect for the following: <ul style="list-style-type: none"> • Loose valve rocker arm studs • Bent valve push rods • Faulty valve springs • Faulty valve lifters (bleeding down) • Worn or improperly seated valves • Worn engine camshaft lobes

Test Procedure

1. Disconnect the positive ignition coil wire plug from ignition coil.
2. Disconnect the fuel injector electrical connector.
3. Remove all the spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery if the battery is not fully charged.
6. Start with the compression gauge at zero. Then crank the engine through four compression strokes (four puffs).
7. Make the compression check the same for each cylinder. Record the reading.

The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1035 \times 70\% = 725$) ($150 \times 70\% = 105$).

8. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
 - Normal — Compression builds up quickly and evenly to the specified compression for each cylinder.
 - Piston Rings Leaking — Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.
 - Valves Leaking — Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
 - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the two cylinders.

SIE-ID - 349121

Engine Noise Diagnosis

Symptom	Cause
<p>When diagnosing engine noise complaints use the following steps to isolate the source of the engine noise:</p> <ul style="list-style-type: none"> Determine the type of noise For example, is the noise a light rattle/tapping or a low rumble/knocking? The exact operating condition under which the noise exists Note factors such as the ambient temperature, the amount of engine warm-up time, the engine temperature, the engine RPM, and other specifics. At what rate the noise occurs, and at what location in the engine Engine noises are generally synchronized to either engine speed (crankshaft, engine flywheel, connecting rods, crankshaft balancer, or pistons and related components) or one-half engine speed (valve train noise such as valve rocker arms, valve lifters, and camshaft timing chain). Determine the rate at which the noise is occurring. Compare the engine sounds to other engines, and make sure you are not trying to correct a normal condition. 	
Noise on Start-Up but Only Lasts a Few Seconds	<ul style="list-style-type: none"> Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. Worn or dirty valve lifters Excessive piston-to-cylinder bore clearance Excessive piston pin-to-bore clearance Excessive crankshaft bearing clearance
Knocks Cold and Continues for 1 to 2 Minutes	<ul style="list-style-type: none"> Loose or broken crankshaft balancer or accessory drive components Excessive piston-to-bore clearance A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinders secondary ignition circuit is grounded out.
Intermittent Noise on Idle, Disappearing When Engine Speed is Increased	<ul style="list-style-type: none"> Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. Lower than specified oil pressure Install an oil pressure gauge and measure the engine oil pressure. Dirty or worn valve lifter
Valve Train Noise (Rattle/Tapping)	<p>The following conditions may cause valve train noise:</p> <ul style="list-style-type: none"> Lower than specified oil pressure Worn or faulty oil pump Loose oil pump-to-engine block bolt Loose valve rocker arm attachments Worn valve rocker arms and/or valve pushrods Broken valve spring Sticking valves Worn, dirty, or faulty valve lifters Worn engine camshaft lobes Worn valve guides or valve stems Bent, broken, or damaged timing chain sprocket teeth

Engine Noise Diagnosis (cont'd)

Symptom	Cause
Knocks Hot at Idle (Rumble/Knocking)	<p>The following conditions may cause a knocking noise:</p> <ul style="list-style-type: none"> • Malfunctioning accessory drive system components • Loose or broken crankshaft balancer • Detonation or spark knock <p>Check for proper operation of the cooling, knock, and ignition control components.</p> <p>Refer to diagnostic information in Engine Controls.</p> <ul style="list-style-type: none"> • Excessive connecting rod bearing clearance • Excessive piston pin-to-bore clearance • Bent connecting rod • Excessive crankshaft bearing clearance • Loose torque converter bolts (if equipped) • Cracked or damaged engine flywheel • Exhaust leak at the exhaust manifold • Combustion chamber deposits
Exhaust System Noise and/or Leakage	<p>Exhaust system noise and/or leakage may be caused by the following conditions:</p> <ul style="list-style-type: none"> • Improperly installed or misaligned exhaust system components • A cracked or broken exhaust manifold • Damaged or worn exhaust manifold gaskets and/or seals • Burnt or rusted out exhaust system components • Broken or loose exhaust clamps and/or brackets

SIE-ID - 348260

Valve Train Diagnosis**General Information**

Symptom	Cause
	<ul style="list-style-type: none"> • A light tapping noise at 1/2 engine speed, or any varying frequency, may indicate a valve train problem. • Tapping noises will typically increase with increased engine speed. • Before attempting to diagnose a valve train noise, check for the proper engine oil level and then allow the engine to obtain normal operating temperature. <p>Following this procedure will bring all engine components to a normal state of expansion.</p> <ul style="list-style-type: none"> • Sit in the driver's seat, then operate the engine at various speeds and listen for any abnormal engine noise.

General Information (cont'd)

Symptom	Cause
Valve Train Noise	<ul style="list-style-type: none"> • Low engine oil pressure • A worn or faulty oil pump • A loose or plugged oil pump screen • Loose valve rocker arm attachments (causing excessive valve lash) • A worn or damaged valve rocker arm ball • A worn valve rocker arm and/or valve pushrod • A broken valve spring • Sticking valves • Valve lifters worn, dirty, or faulty • A broken valve lifter guide • Engine camshaft lobes worn • Worn valve guides or valve stems • Worn or damaged valve stem keys • Bent valve pushrods • Excessive play in the camshaft timing chain • Bent, broken, or damaged camshaft sprocket teeth

Diagnostic Table

Step	Action	Value(s)	Yes	No
DEFINITION: A light tapping noise at 1/2 engine speed, or any varying frequency.				
1	Is there valve train noise?	—	Go to Step 2	System OK
2	Check for a high engine oil level. An engine with the engine oil level above the FULL mark on the oil level indicator allows the crankshaft counterweights to churn the engine oil into foam. When the foamy engine oil is pumped into the valve lifters, the valve lifters become noisy. A solid column of engine oil ensures proper valve lifter operation. Is the engine oil level too high?	—	Go to Step 3	Go to Step 4
3	Drain the engine oil to the proper level. Is the tapping noise gone?	—	System OK	Go to Step 6
4	Check for a low engine oil level. An engine with the engine oil level below the ADD mark on the oil level indicator may allow the oil pump to pump air at high engine RPM. Is the engine oil level below the ADD mark on the oil level indicator?	—	Go to Step 5	Go to Step 6
5	Add the engine oil as required. Is the tapping noise gone?	—	System OK	Go to Step 6
6	Check for the proper engine oil pressure. Refer to <i>Engine Mechanical Specifications (L31 (VIN R)) and Oil Pressure Diagnosis and Testing</i> . Is the engine oil pressure within specifications?	41.4 kPa (6 psi)	Go to Step 11	Go to Step 7
7	Check the oil pump screen for damage or a loose fit to the oil pump. Is the oil pump screen loose or is the oil pump screen damaged?	—	Go to Step 8	Go to Step 9
8	Repair as required. Is the tapping noise gone?	—	System OK	Go to Step 9

Diagnostic Table (cont'd)

Step	Action	Value(s)	Yes	No
9	Check for a damaged oil pump or loose bolts. Refer to <i>Oil Pump Clean and Inspect</i> . Is the oil pump damaged or are the bolts loose?	—	Go to Step 10	Go to Step 11
10	Repair as required. Is the tapping noise gone?	—	System OK	Go to Step 11
11	Remove and inspect the valve lifters, the valve rocker arms, and the valve pushrods. Refer to <i>Valve Rocker Arm and Push Rods Clean and Inspect</i> and <i>Valve Lifters and Guides Clean and Inspect</i> . Are the components worn or damaged?	—	Go to Step 12	Go to Step 13
12	Replace the components as required. Is the tapping noise gone?	—	System OK	Go to Step 13
13	Perform an engine camshaft lobe lift test. Refer to <i>Camshaft and Bearings Clean and Inspect</i> . Is the engine camshaft lobes within specifications?	—	Go to Step 15	Go to Step 14
14	Replace the engine camshaft and valve lifters. Is the tapping noise gone?	—	System OK	Go to Step 15
15	Remove the engine front cover and inspect the camshaft timing chain and sprockets for excessive wear or damage. Refer to <i>Timing Chain and Sprockets Clean and Inspect</i> . Are the components worn or damaged?	—	Go to Step 17	Go to Step 16
16	Replace the components as required. Is the tapping noise gone?	—	System OK	Go to Step 17
17	Perform a complete disassembly of the engine and inspect all components. Are the components worn or damaged?	—	Go to Step 18	System OK
18	Replace the components as required. Did you complete the worn or damaged component replacement?	—	System OK	—

SIE-ID = 69356

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of 1.9 liters (2 quarts) of engine oil within 3 200 kilometers (2,000 miles). However, during initial engine break-in periods 4 828–6 437 kilometers (3,000–4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or more. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten the bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the vehicle on a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components.

- Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream the valve guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly. Allow adequate time for the piston rings to seat. Replace broken or worn piston rings as necessary.
- Piston improperly installed or miss-fitted.

SIE-ID = 23360

Oil Pressure Diagnosis and Testing

1. With the vehicle on a level surface, allow adequate drain down time (2–3 minutes) and measure for a low engine oil level.
Add the recommended grade engine oil, and fill the crankcase until the oil level measures FULL on the oil level indicator.
2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gauge or the oil indicator light.
Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
 - Engine oil diluted by moisture or unburned fuel mixtures
 - Improper engine oil viscosity for the expected temperature
 - Incorrect or faulty oil pressure gauge sensor
 - Incorrect or faulty oil pressure gauge
 - Plugged oil filter
 - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gauge sensor or another engine block oil gallery plug.
5. Install an oil pressure gauge and then measure the engine oil pressure.
6. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
 - Oil pump worn or dirty
 - Malfunctioning oil pump pressure relief valve
 - Oil pump screen loose, plugged, or damaged
 - Excessive bearing clearance
 - Cracked, porous or restricted oil galleries
 - Engine block oil gallery plugs missing or incorrectly installed
 - Broken valve lifters

SIE-ID = 204344

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
DEFINITION: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.				
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to <i>Engine Mechanical Specifications</i> . 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait (15 minutes). 4. Check for drippings. 5. Are drippings present?	—	Go to Step 2	Go to Step 3
2	1. Identify the type of fluid and the approximate location of the leak. 2. Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components 3. Can you identify the source of the leak?	—	Go to Step 10	Go to Step 4

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
4	<ol style="list-style-type: none"> 1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait (15 minutes). 5. Identify the type of fluid, and the approximate location of the leak. 6. Can you identify the type of fluid and the approximate location of the leak? 	—	Go to Step 10	Go to Step 5
5	<ol style="list-style-type: none"> 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components 3. Can you identify the source of the leak? 	—	Go to Step 10	Go to Step 6
6	<ol style="list-style-type: none"> 1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. 5. Can you identify the type of fluid and the approximate location of the leak? 	—	Go to Step 10	Go to Step 7
7	<ol style="list-style-type: none"> 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components 3. Can you identify the source of the leak? 	—	Go to Step 10	Go to Step 8
8	<ol style="list-style-type: none"> 1. Using the J 28428-E, Dye and Light Kit, identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. 2. Can you identify the type of fluid and the approximate location of the leak? 	—	Go to Step 10	Go to Step 9
9	<ol style="list-style-type: none"> 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components 3. Can you identify the source of the leak? 	—	Go to Step 10	Go to Step 12

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Check for the following conditions: <ul style="list-style-type: none"> • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Is there mechanical damage to the engine?	—	Go to Step 11	—
11	Repair or replace all damaged components.	—	Go to Step 1	—
12	System OK.	—	—	—

SIE-ID = 371679

Drive Belt Diagnosis**Definitions**

The following are symptomatic noises of the drive belt system:

Chirping

The following items are indications of chirping:

- A high pitched noise that is usually heard once per revolution of a pulley or a belt.
- It is most common on cold, damp mornings.
- Verify this condition by squirting water onto the belt. The noise will momentarily stop.

Squeal

The following items are indications of squeal:

- A loud screeching noise that is caused by a slipping belt (this is unusual for a belt with multiple ribs).
- The noise occurs when a heavy load is applied to the belt, such as an air conditioning compressor engagement, snapping the throttle, or slipping on a seized pulley.

Whine

A high pitched continuous noise that may be caused by a failed bearing.

Faint Cycle Rumbling

A low frequency noise heard once per revolution of the drive belt.

Pilling

The following items are indications of pilling:

- The random accumulation of rubber dust in the bottom of the multi-ribbed belt grooves.
- A small amount of pilling is normal.
- Operation of the drive belt system will not be effected unless the buildup exceeds one third (1/3) of the belt groove depth.

Multiple-ribbed type drive belts wear evenly with their

pulleys. Unusual wear indicates a correction is needed. The following diagnostic tables will aid in diagnosing drive belt system conditions.

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
1	Check for misalignment of the pulleys. Are any of the pulleys misaligned?	—	Go to Step 2	Go to Step 3
2	Replace any misaligned pulleys. Is the chirp still present?	—	Go to Step 3	System OK
3	Check for bent or cracked brackets. Are there any bent or cracked brackets?	—	Go to Step 4	Go to Step 5
4	Replace any bent or cracked brackets. Is the chirp still present?	—	Go to Step 5	System OK
5	Check for any loose or missing fasteners. Are there any loose or missing fasteners?	—	Go to Step 6	Go to Step 7
6	Tighten any loose fasteners and properly install any missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Is the chirp still present?	—	Go to Step 7	System OK
7	Check for a bent pulley flange. Is the pulley flange bent?	—	Go to Step 8	Go to Step 9
8	Replace the pulley flange. Is the chirp still present?	—	Go to Step 9	System OK
9	Check for severe pilling, exceeding 1/3 of the belt groove depth. Is there severe pilling?	—	Go to Step 10	—
10	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Is the chirp still present?	—	—	System OK

Drive Belt Squeal

Step	Action	Value(s)	Yes	No
11	Check for a misaligned pulley. Is there a pulley misaligned?	—	Go to Step 13	Go to Step 12
12	Check for incorrect belt length. Refer to <i>Drive Belt Replacement</i> . Is the belt length correct?	—	Go to Step 14	Go to Step 15
13	Repair or install new parts as necessary. Is the repair complete?	—	System OK	—
14	Check for a malfunctioning drive belt tensioner. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Is the tensioner malfunctioning?	—	Go to Step 13	Go to Step 15
15	Check for correct pulley size. Are the pulleys the correct size?	—	Go to Step 16	Go to Step 13
16	Check for seized bearings. Is there a seized bearing?	—	Go to Step 13	System OK

Drive Belt Whine

Step	Action	Value	Yes	No
17	Check for a worn accessory component bearing. Is a bearing making the noise?	—	Go to Step 18	System OK
18	Install new parts as necessary. Is the repair complete?	—	System OK	—

Drive Belt Rumbling

Step	Action	Value(s)	Yes	No
19	Check for severe pilling. Is there severe pilling of more than 1/3 of the rib depth?	—	Go to Step 19	System OK
20	Clean the drive belt pulleys. Are the drive belt pulleys clean?	—	Go to Step 20	Go to Step 21
21	Install a new drive belt. Is the repair complete?	—	System OK	—

Drive Belt Vibration

Step	Action	Value(s)	Yes	No
22	Check for loose or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Are there loose or missing fasteners?	—	Go to Step 22	Go to Step 24
23	Re-tighten or replace as necessary. Is the repair complete?	—	System OK	—
24	Check for damaged fan blades. Are there damaged fan blades?	—	Go to Step 25	Go to Step 26
25	Replace as necessary. Refer to Fan Blade Replacement in Engine Cooling. Is the replacement complete?	—	System OK	—
26	Check for a bent fan clutch or coolant pump shaft. Is the fan clutch or coolant pump shaft bent?	—	Go to Step 27	Go to Step 28
27	Replace as necessary. Refer to Water Pump Replacement in Engine Cooling. Is the repair complete?	—	System OK	—
28	Check for bent or cracked brackets. Are there bent or cracked brackets?	—	Go to Step 29	System OK
29	Replace the brackets as necessary. Is the repair complete?	—	System OK	—

Drive Belt Falls Off

Step	Action	Value(s)	Yes	No
30	Check for a misaligned or a bent pulley. Are the pulleys misaligned?	—	Go to Step 31	Go to Step 32
31	Replace any misaligned or bent pulleys. Does the drive belt continue to fall off?	—	Go to Step 32	System OK
32	Check for a bent or a cracked bracket. Are any of the brackets bent or cracked?	—	Go to Step 33	Go to Step 34
33	Replace the damaged brackets. Does the drive belt continue to fall off?	—	Go to Step 34	System OK
34	Check for loose or missing fasteners. Are there any loose or missing fasteners?	—	Go to Step 35	Go to Step 36
35	Replace any missing fasteners and tighten to specifications. Refer to <i>Fastener Tightening Specifications</i> . Does the drive belt continue to fall off?	—	Go to Step 36	System OK
36	Check for a misaligned power steering pump pulley. Is the power steering pump pulley misaligned?	—	Go to Step 37	Go to Step 38

Drive Belt Falls Off (cont'd)

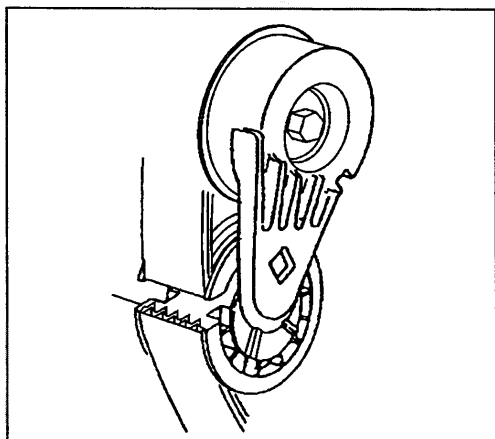
Step	Action	Value(s)	Yes	No
37	Realign or replace the power steering pump pulley. Refer to Power Steering Pump Replacement in Power Steering. Does the drive belt continue to fall off?	—	Go to Step 38	System OK
38	Check for a damaged drive belt. Is the drive belt damaged?	—	Go to Step 39	Go to Step 40
39	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Does the drive belt continue to fall off?	—	Go to Step 40	System OK
40	Check for a malfunctioning drive belt tensioner. Is the drive belt tensioner malfunctioning?	—	Go to Step 41	Go to Step 42
41	Replace the drive belt tensioner. Does the drive belt continue to fall off?	—	Go to Step 42	System OK
42	Check for worn idler or tensioner pulley bearings. Are the idler or tensioner pulley bearings worn?	—	Go to Step 43	—
43	Replace the worn bearings. Does the drive belt continue to fall off?	—	—	System OK

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
44	Check to see if the ribs in the drive belt do not match the grooves in the pulley. Do the ribs in the drive belt match the grooves in the pulley?	—	—	Go to Step 45
45	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Is there still excessive wear in either outside groove of the drive belt?	—	—	System OK

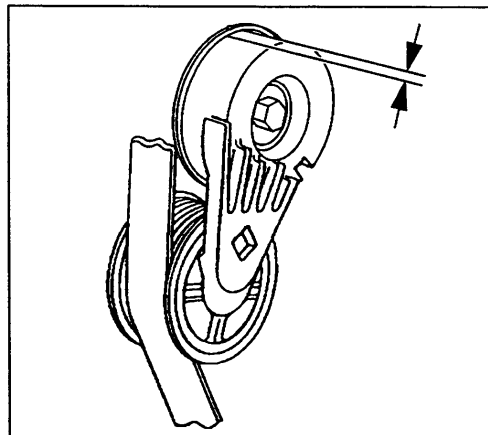
General Instructions

The following graphics illustrate the correct way to route the drive belt over the pulleys, and some examples of incorrect belt placement.

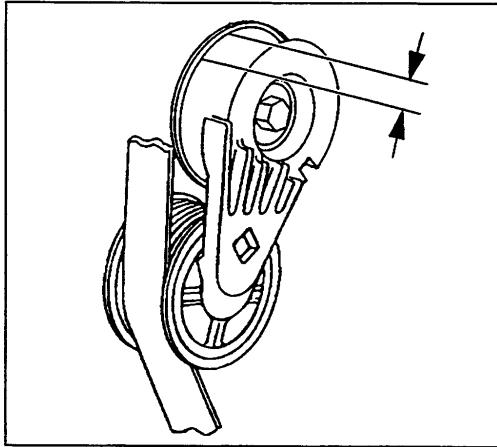


1. Observe the drive belt correctly installed on the

pulley. Each groove on the drive belt rests inside a matching groove in the pulley.

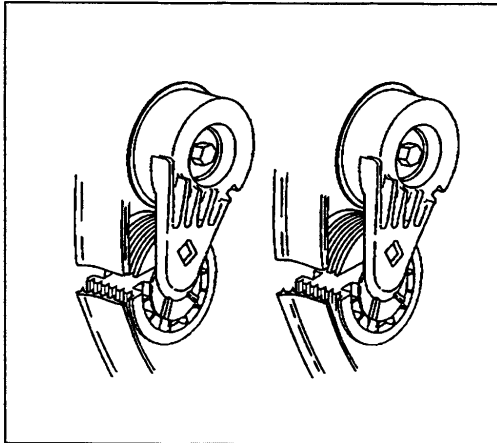


2. When installing a new drive belt, observe the indicator on the tensioner. A new drive belt should fall inside this range.



172991

3. When installing a used drive belt, observe the indicator on the tensioner. A used drive belt should fall inside this range.



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4. Observe these incorrectly installed drive belts: Avoid mis-positioning the belt by one or more grooves.

SIE-ID = 332331

Drive Belt Tensioner Diagnosis

Inspection Procedure

Notice: SIO-ID = 3753 Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the belt tensioner through its full travel.
 - The movement should feel smooth.

- There should be no binding.
 - The drive belt tensioner should return freely.
4. If any binding is observed, replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
 5. Install the drive belt. Refer to *Drive Belt Replacement*.

Important: Please note that movement of the Drive Belt Tensioner while the engine is operating is considered a normal operating condition. The Drive Belt Tensioner should not be replaced for this normal operating condition.

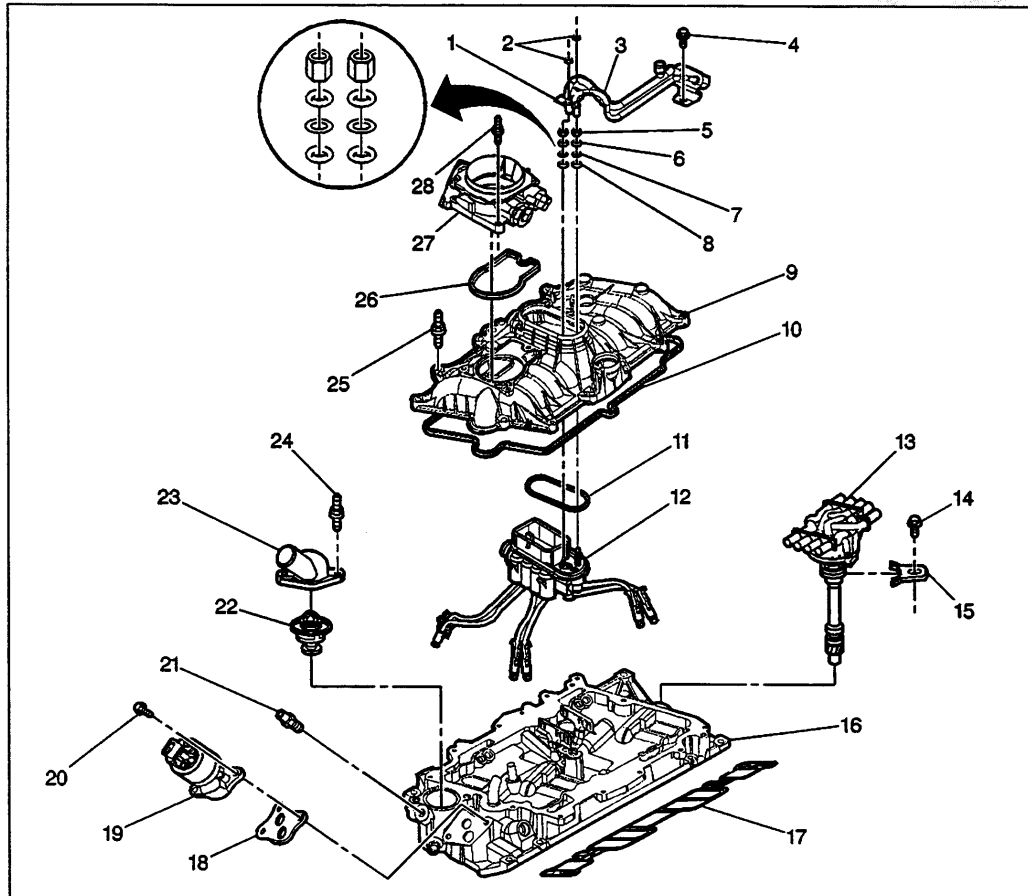
Visual Identification

SIE-ID - 348556

Disassembled Views

SIO-ID - 67224

Intake Manifolds and Components



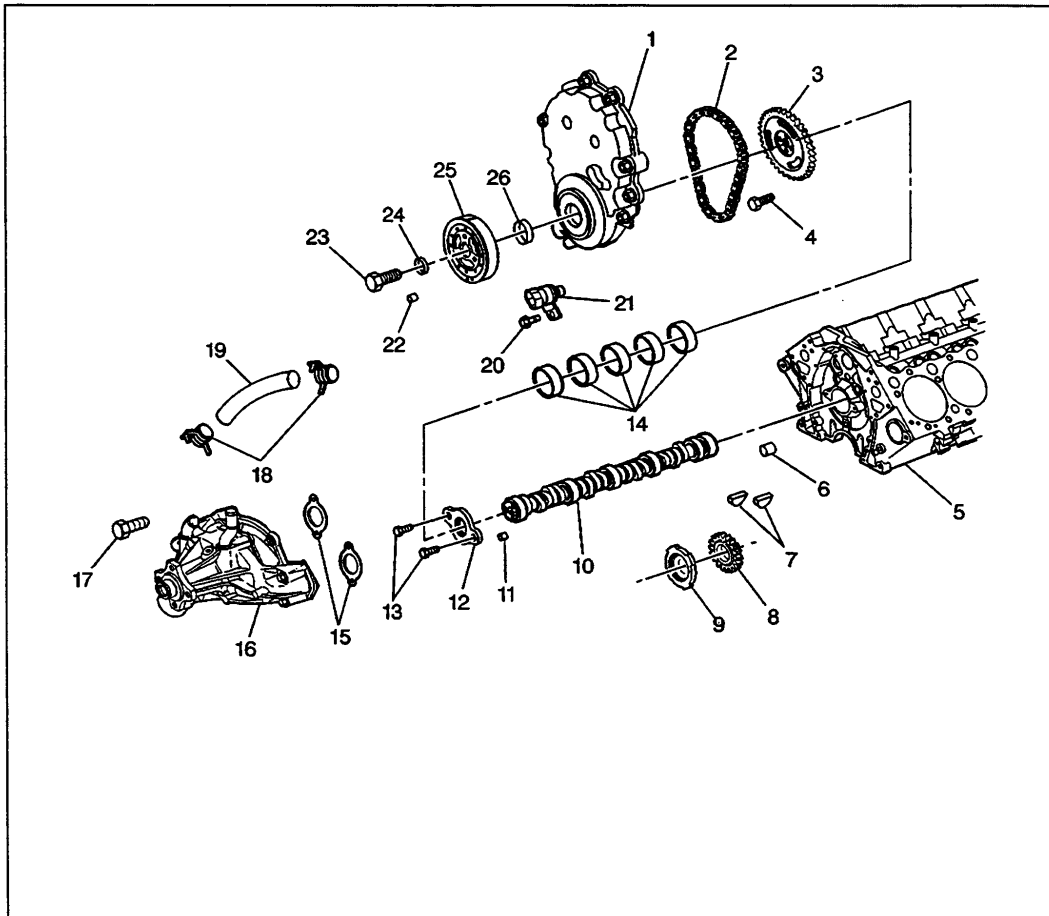
Legend

- | | |
|---|-----------------------------------|
| (1) Fuel Pipe Retainer Bracket | (12) TBI Fuel Meter |
| (2) Fuel Pipe Retainer Bracket Nuts | (13) Distributor |
| (3) Fuel Pipe | (14) Hex Bolt (Distributor Clamp) |
| (4) Fuel Pipe Attachment Screw | (15) Distributor Clamp |
| (5) Fuel Seal Retainer | (16) Lower Intake Manifold |
| (6) Fuel Seal (Yellow O-ring) | (17) Lower Intake Manifold Gasket |
| (7) Spacer Ring (Flat Washer) | (18) EGR Valve Gasket |
| (8) Fuel Seal (Black O-ring) | (19) EGR Valve |
| (9) Upper Intake Manifold | (20) EGR Valve Bolt |
| (10) Upper Intake Manifold to Lower Intake Gasket | (21) Engine Coolant Sensor |
| (11) Fuel Meter Body Seal | (22) Engine Coolant Thermostat |

- (23) Water Outlet
- (24) Water Outlet Stud
- (25) Upper Intake Manifold Stud
- (26) Throttle Body Gasket
- (27) Throttle Body
- (28) Throttle Body Attaching Stud

SIO-ID - 197523

Front of Engine



182828

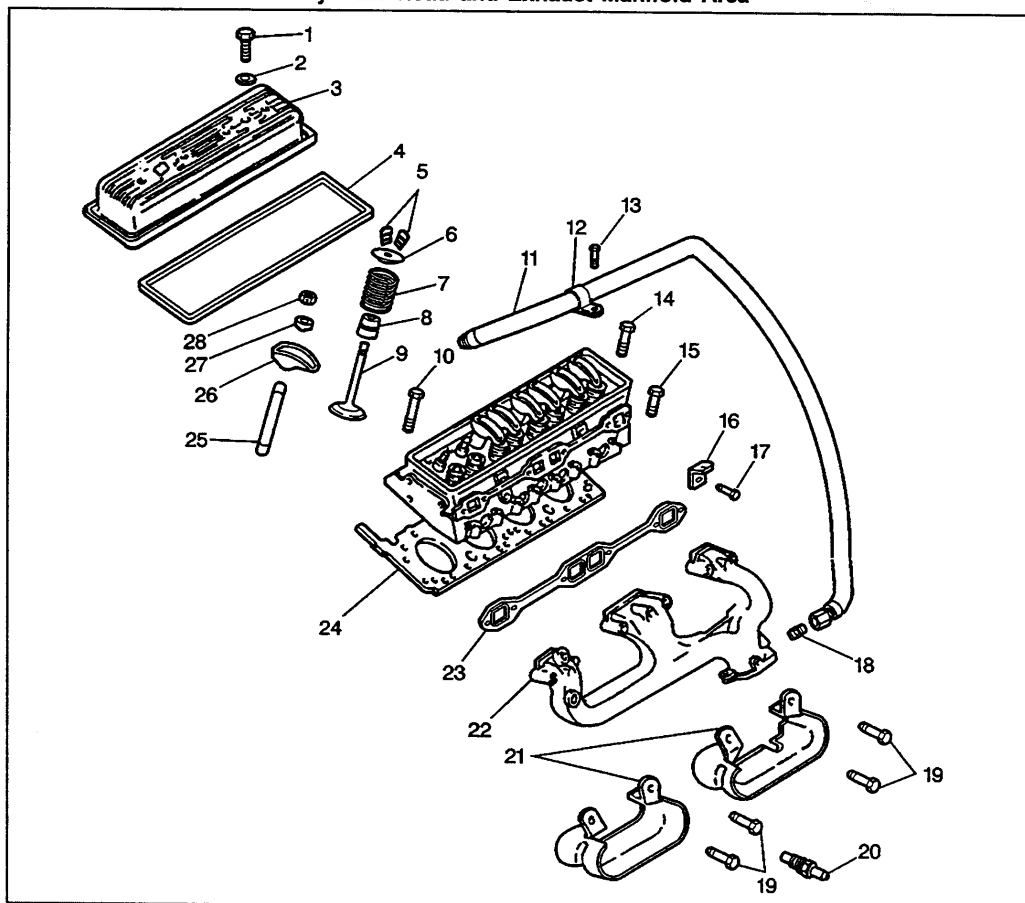
Legend

- | | |
|--|---------------------------------------|
| (1) Engine Front Cover | (9) Crankshaft Position Reluctor Ring |
| (2) Camshaft Timing Chain | (10) Engine Camshaft |
| (3) Camshaft Sprocket | (11) Camshaft Sprocket Locator Pin |
| (4) Camshaft Sprocket Bolt | (12) Camshaft Retainer |
| (5) Engine Block | (13) Camshaft Retainer Bolt |
| (6) Engine Block Oil Gallery Plug | (14) Camshaft Bearings |
| (7) Woodruff Key (Crankshaft Balancer) | (15) Water Pump Gasket |
| (8) Crankshaft Sprocket | (16) Water Pump |

- (17) Water Pump Bolt
- (18) Water Pump Inlet Hose Clamp
- (19) Water Pump Inlet Hose
- (20) Crankshaft Position Sensor Bolt
- (21) Crankshaft Position Sensor
- (22) Front Groove Pin (Crankshaft Balancer)
- (23) Crankshaft Balancer Bolt
- (24) Crankshaft Balancer Bolt Washer
- (25) Crankshaft Balancer
- (26) Crankshaft Front Oil Seal

SIO-ID = 197712

Cylinder Head and Exhaust Manifold Area



182825

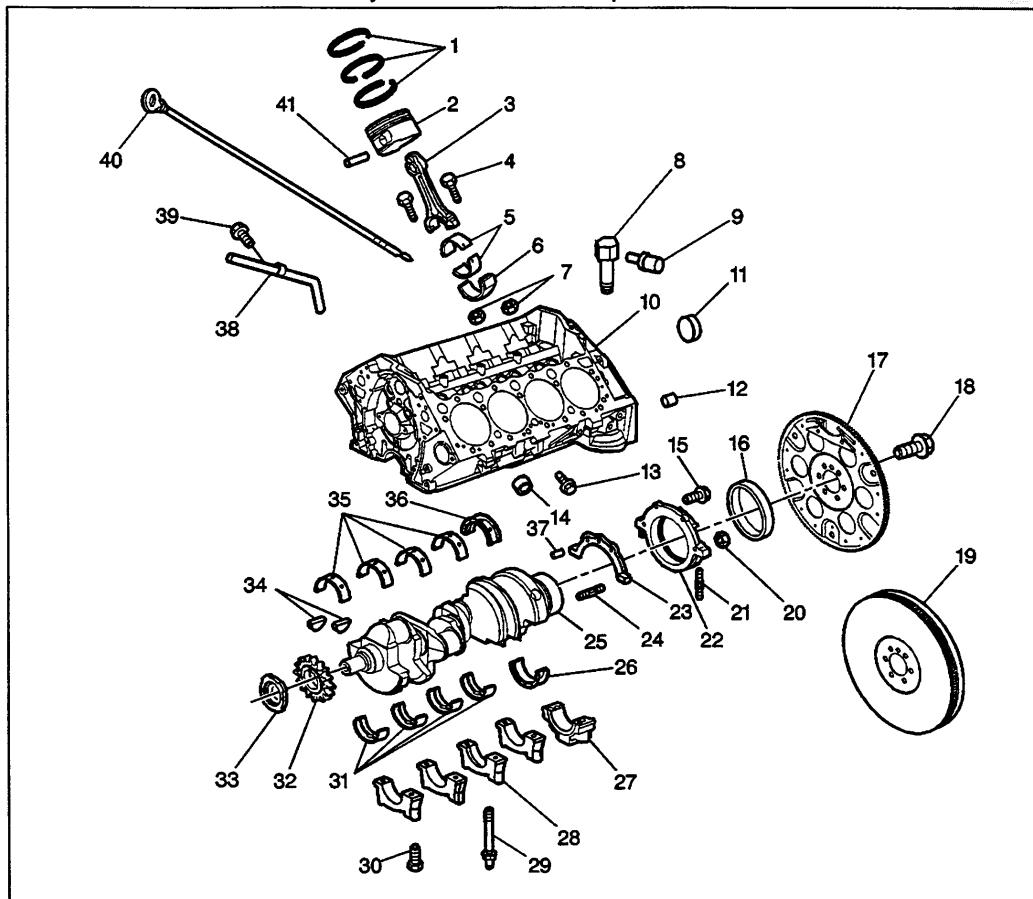
Legend

- | | |
|--|-------------------------|
| (1) Valve Rocker Arm Cover Bolt | (5) Valve Stem Keys |
| (2) Valve Rocker Arm Cover Bolt Washer | (6) Valve Spring Cap |
| (3) Valve Rocker Arm Cover | (7) Valve Spring |
| (4) Valve Rocker Arm Cover Gasket | (8) Valve Stem Oil Seal |

- (9) Valve
- (10) Cylinder Head Bolt (Long)
- (11) EGR Valve Pipe
- (12) EGR Valve Pipe Clamp
- (13) EGR Valve Pipe Clamp Bracket Bolt
- (14) Cylinder Head Bolt (Medium)
- (15) Cylinder Head Bolt (Short)
- (16) Spark Plug Wire Support Bracket
- (17) Spark Plug Wire Support Bracket Bolt
- (18) EGR Valve Pipe Fitting
- (19) Exhaust Manifold Bolts
- (20) Engine Coolant Temperature (ECT) Gauge
Sensor
- (21) Spark Plug*Wire Shields
- (22) Exhaust Manifold
- (23) Exhaust Manifold Gasket
- (24) Cylinder Head Gasket
- (25) Valve Pushrod
- (26) Valve Rocker Arm
- (27) Valve Rocker Arm Ball
- (28) Valve Rocker Arm Nut

SIO-ID - 348439

Cylinder Block and Components



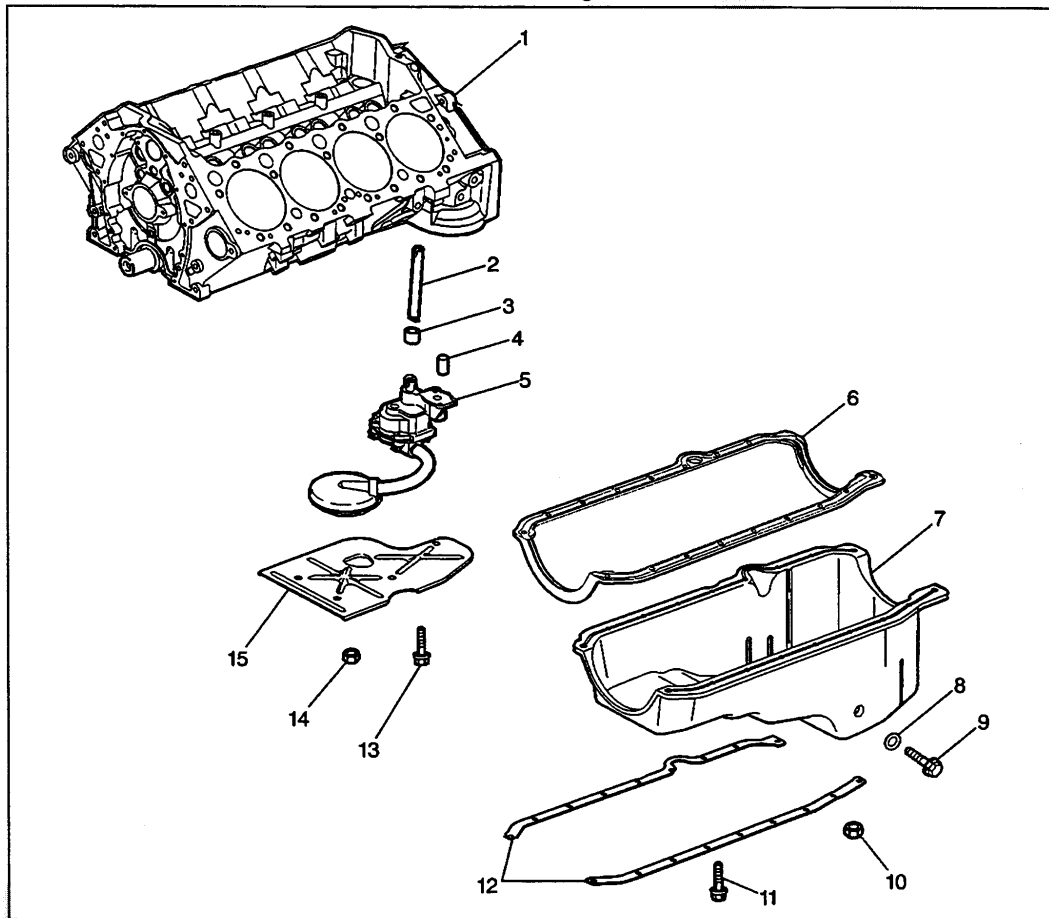
317429

Legend

- | | |
|--|---|
| (1) Piston Ring Kit | (16) Crankshaft Rear Oil Seal |
| (2) Piston | (17) Engine Flywheel (Automatic Transmission) |
| (3) Connecting Rod | (18) Flywheel Bolt |
| (4) Connecting Rod Bolt | (19) Engine Flywheel (Manual Transmission) |
| (5) Connecting Rod Bearings | (20) Crankshaft Rear Oil Seal Housing Nut |
| (6) Connecting Rod Cap | (21) Crankshaft Rear Oil Seal Housing Stud |
| (7) Hex Nut (Connecting Rod) | (22) Crankshaft Rear Oil Seal Housing |
| (8) Engine Oil Pressure Gauge Sensor Fitting | (23) Crankshaft Rear Oil Seal Housing Gasket |
| (9) Engine Oil Pressure Gauge Sensor | (24) Crankshaft Rear Oil Seal Housing Stud |
| (10) Engine Block | (25) Crankshaft |
| (11) Expansion Cup Plug (Camshaft Rear Bearing Hole) | (26) Crankshaft Bearing (Rear Thrust Bearing) |
| (12) Dowel Straight Pin (Transmission Locator) | (27) Crankshaft Bearing Cap (Rear) |
| (13) Engine Block Coolant Drain Hole Plug | (28) Crankshaft Bearing Cap |
| (14) Engine Block Core Hole Plug | (29) Crankshaft Bearing Cap Stud |
| (15) Crankshaft Rear Oil Seal Housing Bolt | (30) Crankshaft Bearing Cap Bolt |
| | (31) Crankshaft Bearings |

- (32) Crankshaft Sprocket
- (33) Crankshaft Position Sensor Reluctor Ring
- (34) Woodruff Keys (Crankshaft Balancer)
- (35) Crankshaft Bearing
- (36) Crankshaft Bearing (Rear Thrust Bearing)
- (37) Spring Type S Pin (Crankshaft Rear Oil Seal Housing Locator)
- (38) Oil Level Indicator Tube
- (39) Oil Level Indicator Tube Bolt
- (40) Oil Level Indicator
- (41) Piston Pin

SIO-ID - 197524

Bottom of Engine

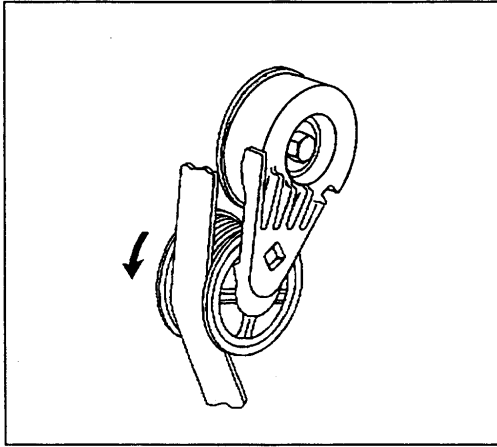
182829

Legend

- | | |
|----------------------------------|--------------------------------------|
| (1) Engine Block | (5) Oil Pump |
| (2) Oil Pump Driveshaft | (6) Oil Pan Gasket |
| (3) Oil Pump Driveshaft Retainer | (7) Oil Pan |
| (4) Pin (Oil Pump Locator) | (8) Oil Pan Drain Plug Seal (O-ring) |

Engine**Engine Mechanical - 5.0L, 5.7L 6-33**

- (9) Oil Pan Drain Plug
 - (10) Oil Pan Nut
 - (11) Oil Pan Bolt
 - (12) Oil Pan Reinforcement
 - (13) Crankshaft Oil Deflector Bolt
 - (14) Crankshaft Oil Deflector Nut
 - (15) Crankshaft Oil Deflector
-



177620

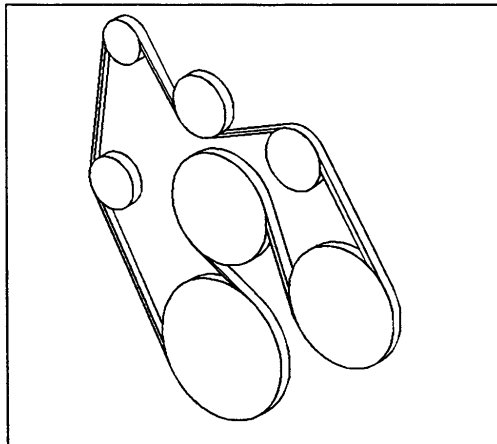
Repair Instructions

SIE-ID - 332317

Drive Belt Replacement

Removal Procedure

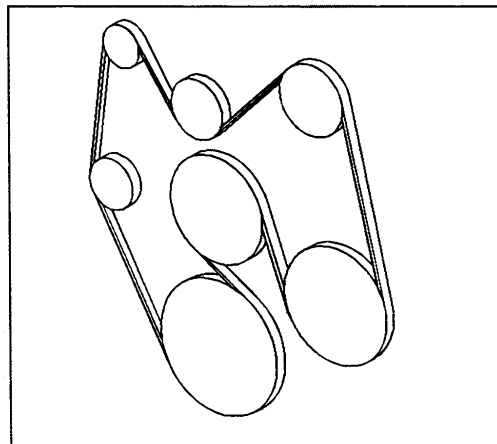
1. Install a 3/8 inch drive wrench on the drive belt tensioner and rotate the arm counterclockwise.
2. Remove the drive belt.
3. Slowly release the tension on the drive belt tensioner.



43858

Installation Procedure

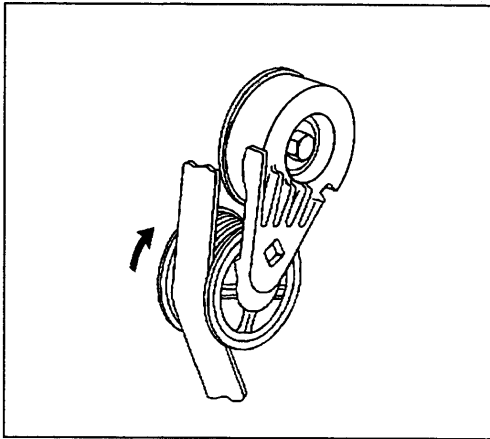
1. Route the belt over all the pulleys except the drive belt tensioner.
2. Observe belt routing for vehicles without air conditioning.



43859

3. Observe belt routing for vehicles with air conditioning.

4. Install a 3/8 inch drive wrench on the drive belt tensioner and rotate the arm counterclockwise.
5. Install the belt over the drive belt tensioner pulley.
6. Slowly release the tension on the drive belt tensioner.
7. Confirm that the belt is properly routed.



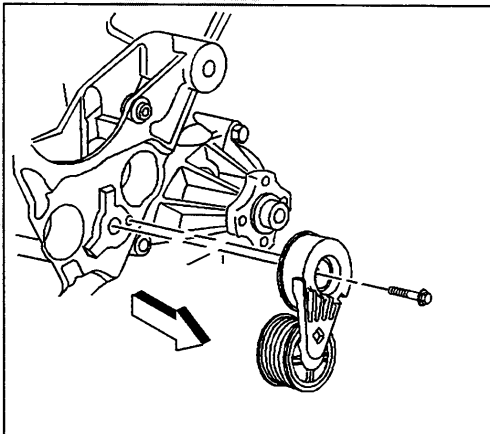
177622

SIE-ID = 332333

Drive Belt Tensioner Replacement

Removal Procedure

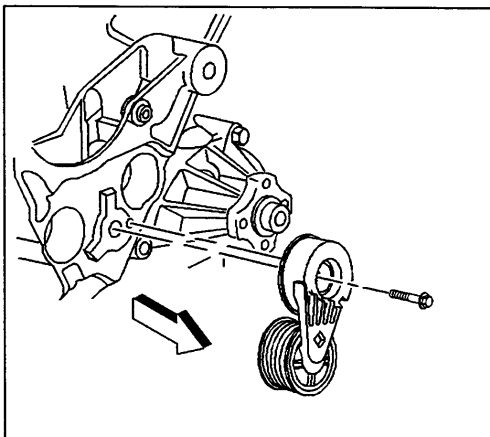
1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the bolt.
3. Remove the drive belt tensioner.



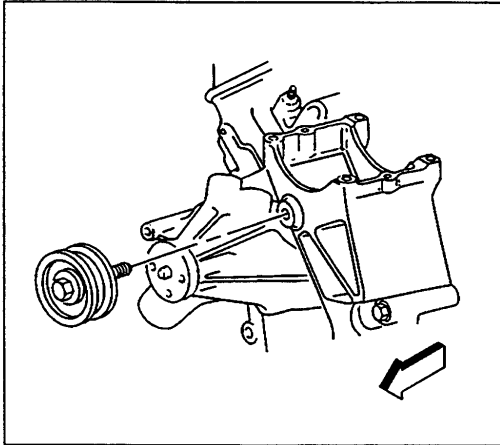
43854

Installation Procedure

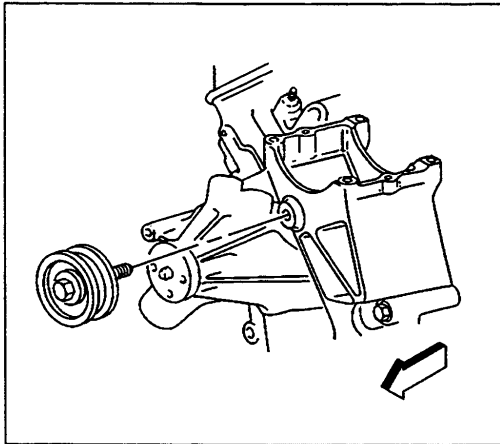
1. Install the belt tensioner assembly.
Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the attaching bolt.
Tighten
 Tighten the drive belt tensioner assembly bolt to 50 N.m (37 lb ft).
3. Install the drive belt. Refer to *Drive Belt Replacement* (**ERROR - NOT IN CURRENT PSD**).



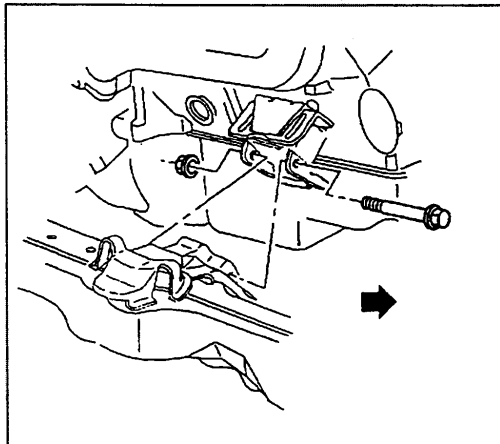
43854



188927



188927



4564

SIE-ID - 332337

Drive Belt Idler Pulley Replacement**Removal Procedure**

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the belt idler pulley bolt.
3. Remove the belt idler pulley.

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the belt idler pulley and bolt to the power steering bracket.

Tighten

Tighten the bolt to 50 N·m (37 lb ft).

2. Install the drive belt. Refer to *Drive Belt Replacement*.

SIE-ID - 332340

Engine Mount Inspection (Front)

Notice: SIO-ID - 5167 Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Notice: SIO-ID - 221323 When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Lifting the engine in an unapproved manner may cause component damage.

1. Raise the engine in order to complete the following tasks:
 - Remove weight from the mount.
 - Place a slight tension on the rubber cushion.
 - Observe the mount while raising the engine.
2. Replace the mount if the following conditions

exist:

- Heat check cracks cover the hard rubber surface
 - The rubber cushion is separated from the metal plate of the mount
 - There is a split through the rubber cushion.
3. If the mount is loose, lower the engine and tighten the bolts or the nuts to the engine frame or the bracket. Refer to *Fastener Tightening Specifications*.

SIE-ID = 332362

Engine Mount Replacement (Front C Model)

SIO-ID = 67154

Removal Procedure

Notice: SIO-ID = 16639 When supporting the engine to replace a mounting, raise the engine only to the height required to provide clearance for mounting removal. It may be necessary to drain the cooling system and disconnect hoses to avoid damage when the engine is raised. Be careful that control linkage and wiring are not damaged from raising the engine. When replacing a single front mounting, both mountings, should be detached before attempting to raise the engine. Failure to do this will place excessive stress on the attached mounting when the engine is raised.

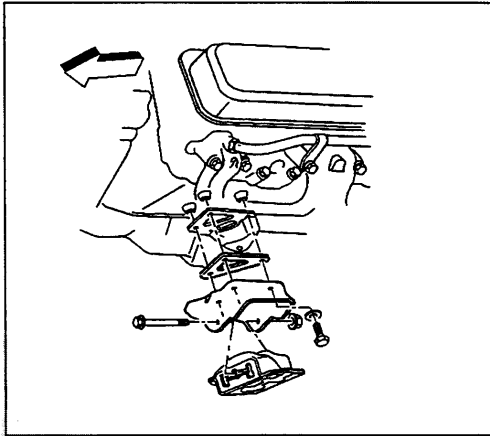
1. Support the engine with a suitable jack. Do not load the engine mounting.

Notice: SIO-ID = 16544 Raise the engine to allow sufficient clearance. Distributor damage results from interference between the rear of the engine and the dash panel.

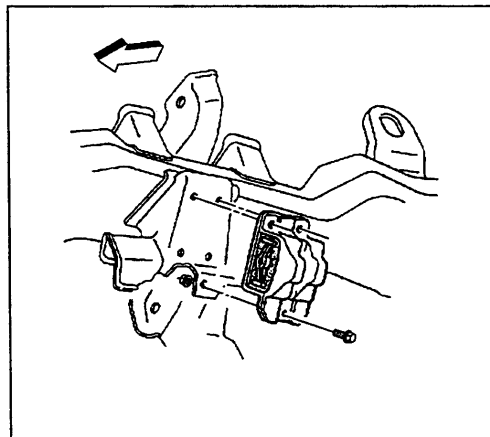
2. Raise the engine only enough in order to permit removal of the engine mounting.

Remove the engine mounting through-bolt and nut.

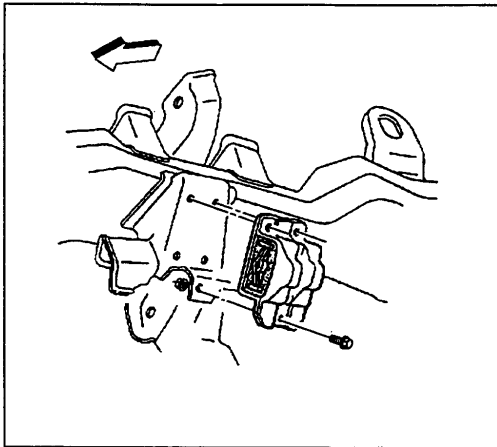
3. Remove the mounting assembly bolts, nuts, and washers.
4. Remove the mounting assembly.



66191



66190



66190

SIO-ID = 67155

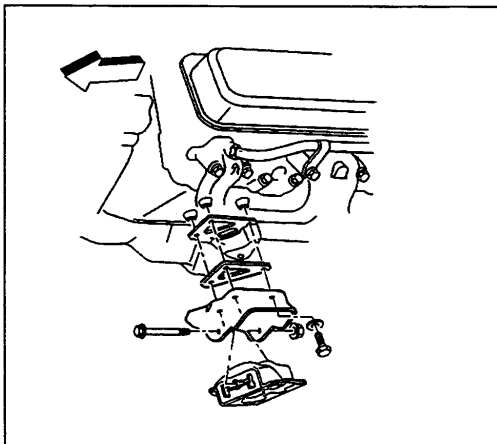
Installation Procedure

1. Install the mounting assembly.
2. Install the mounting assembly bolts, nuts, and washers.

Tighten

- Tighten the bolts to 59 N-m (44 lb ft).
- Tighten the nuts to 45 N-m (33 lb ft).

Notice: Refer to *Fastener Notice* in General Information.



66191

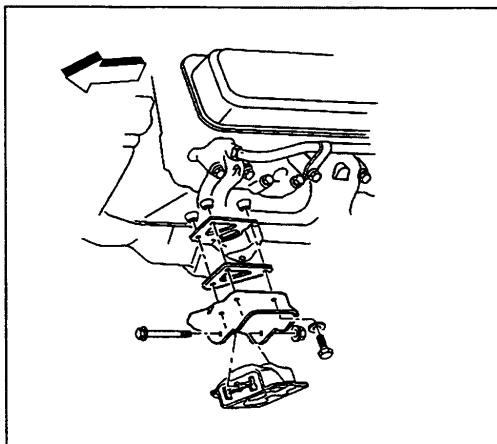
3. Install the engine mount through-bolt and nut.

- 3.1. Lower the engine until the bolt can be inserted.

- 3.2. Install the through-bolt nut.

Tighten

Tighten the nut to 68 N-m (50 lb ft).



66191

SIE-ID = 332376

Engine Mount Replacement (Front C Model)

SIO-ID = 67151

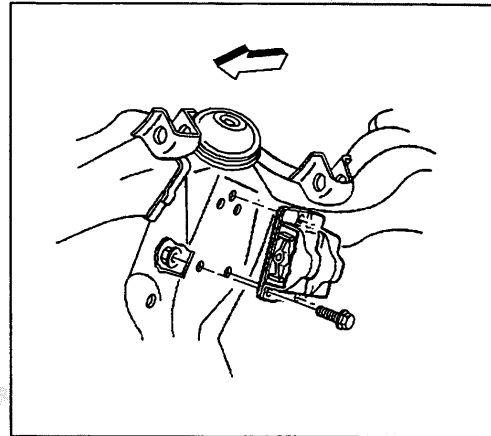
Removal Procedure

Notice: SIO-ID = 16639 When supporting the engine to replace a mounting, raise the engine only to the height required to provide clearance for mounting removal. It may be necessary to drain the cooling system and disconnect hoses to avoid damage when the engine is raised. Be careful that control linkage and wiring are not damaged from raising the engine. When replacing a single front mounting, both mountings, should be detached before attempting to raise the engine. Failure to do this will place excessive stress on the attached mounting when the engine is raised.

1. Support the engine with a suitable jack. Do not load the engine mounting.

Notice: SIO-ID = 16544 Raise the engine to allow sufficient clearance. Distributor damage results from interference between the rear of the engine and the dash panel.

2. Raise the engine only enough to permit removal of the engine mounting.
3. Remove the engine mounting through-bolt and the nut.
4. Remove the mounting assembly bolts, nuts, and washers.
5. Remove the mounting assembly.



66189

SIO-ID = 67153

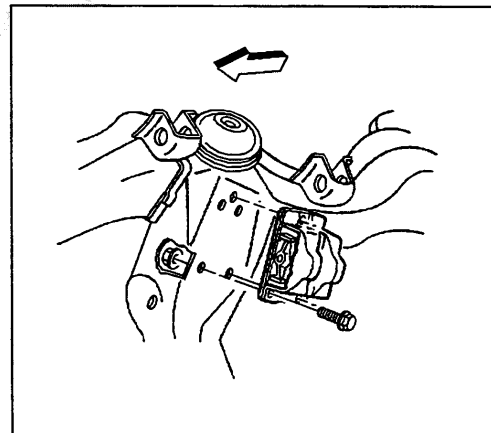
Installation Procedure

1. Install the mounting assembly.
2. Install the mounting assembly bolts, nuts, and washers.

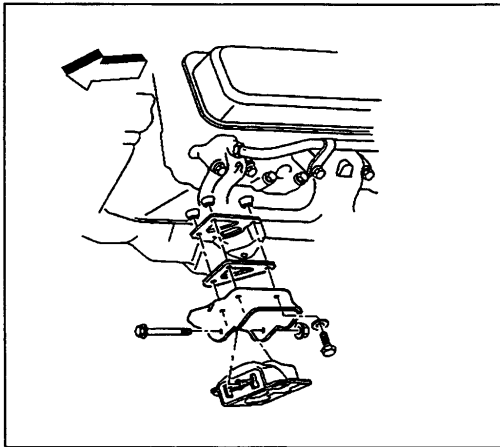
Tighten

- Tighten the bolts to 59 N.m(44 lb ft).
- Tighten the nuts to 45 N.m (33 lb ft).

Notice: Refer to *Fastener Notice* in General Information.



66189



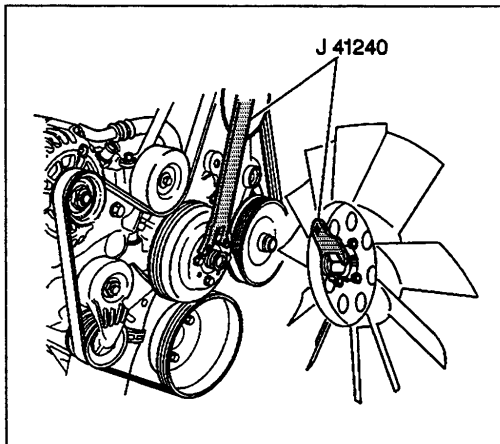
66191

3. Install the engine mount through-bolt and nut.
- 3.1. Lower the engine until the bolt can be inserted.

- 3.2. Install the through-bolt nut.

Tighten

Tighten the nut to 68 N.m (50 lb ft).



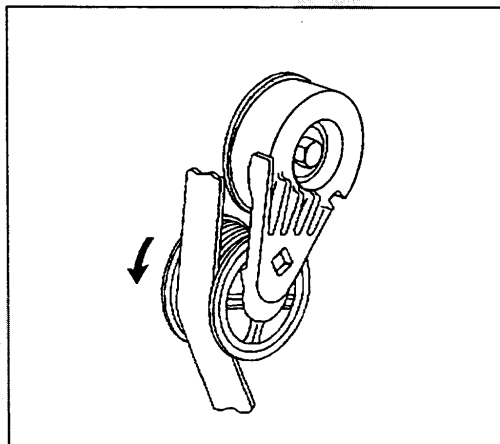
42910

SIE-ID - 358133

Accessory Mounting Brackets Replacement (AC Equipped)

Removal Procedure

1. Remove the engine cooling fan. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)* in Engine Cooling.



177620

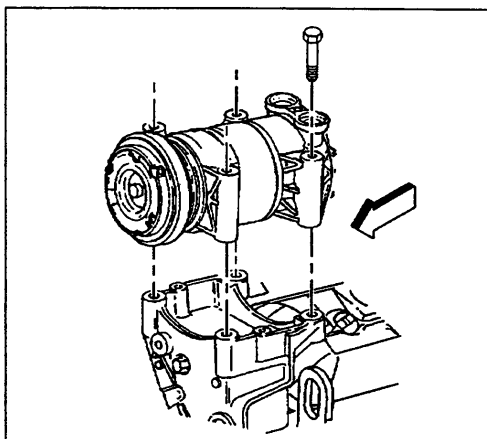
2. Remove the drive belt. Refer to *Drive Belt Replacement*.

Engine

Engine Mechanical - 5.0L, 5.7L 6-41

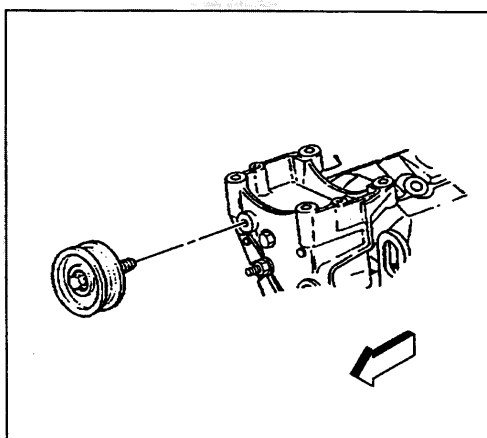
Important: Do not evacuate the air conditioning system.

3. Remove the mounting bolts for the air conditioning compressor, if equipped.
4. Move the air conditioning compressor aside and support.



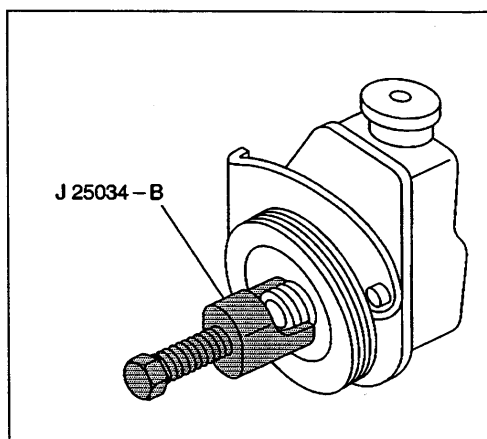
179249

5. Remove the belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement*.

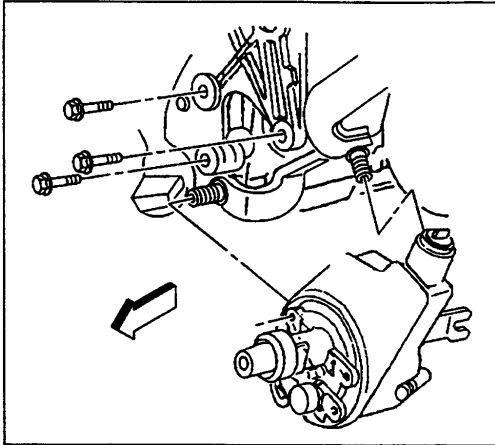


338506

6. Remove the power steering pump pulley.

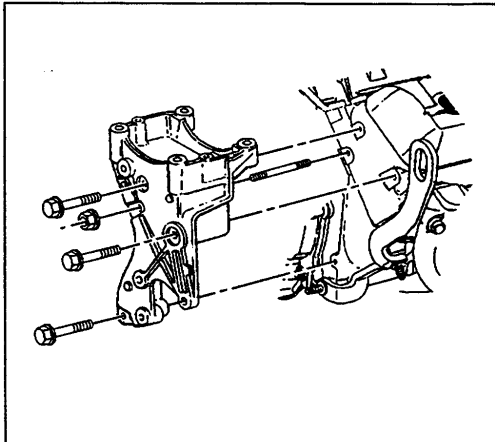


188649



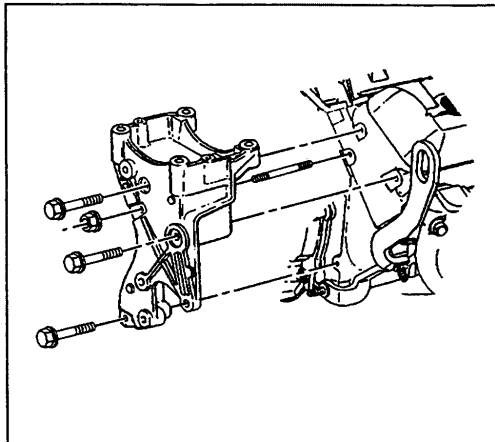
288829

7. Remove the bolts and nuts holding the power steering pump to the accessory mounting bracket.



188295

8. Remove the three bolts and nut holding the accessory mounting bracket to the engine.
9. Slide the accessory mounting bracket off the stud and power steering pump.



188295

Installation Procedure

1. Slide the bracket on the stud and the power steering pump.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the three bolts and the nut.

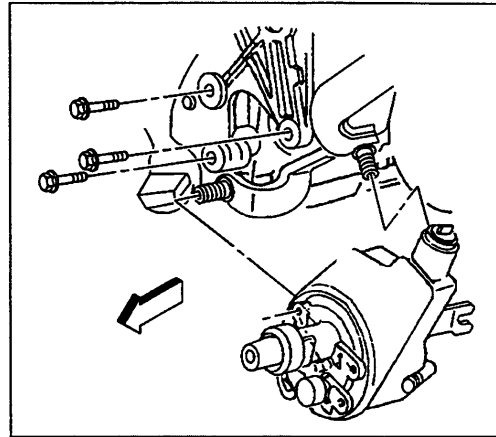
Tighten

Tighten the bolts and nut to 41 N.m (30 lb ft).

3. Install the bolts and nuts for the power steering pump.

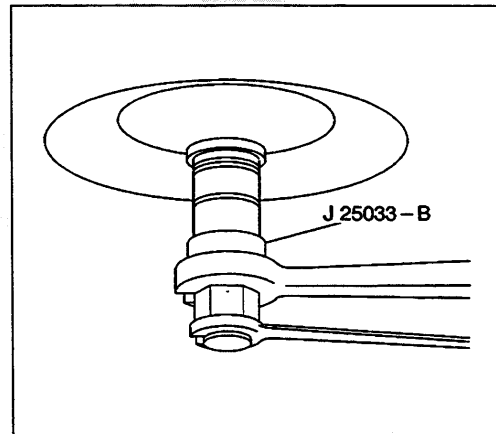
Tighten

Tighten the bolts and nuts to 41 N·m (30 lb ft).



288829

4. Install the power steering pump pulley.

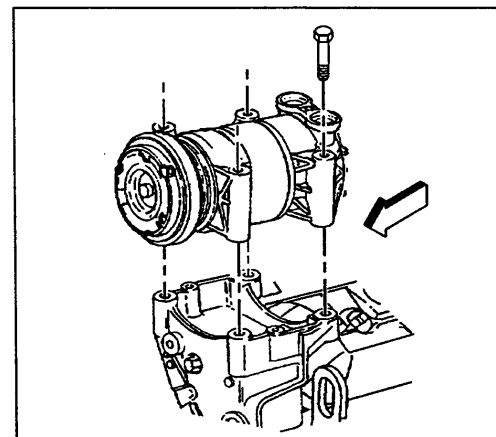


188373

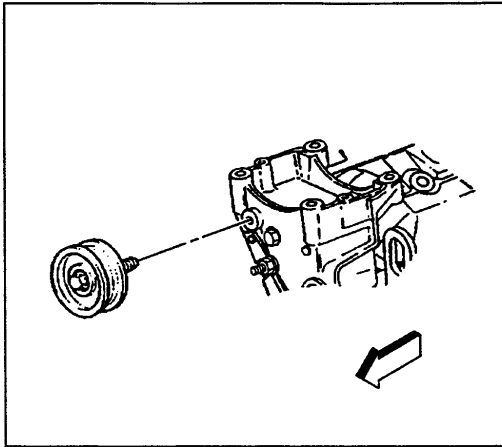
5. Install the air conditioning compressor bolts.

Tighten

Tighten the bolts to 50 N·m (37 lb ft).



179249

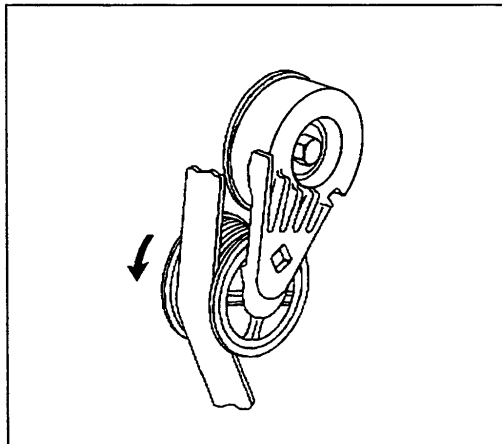


338506

6. Install the belt idler pulley if not equipped with A/C.

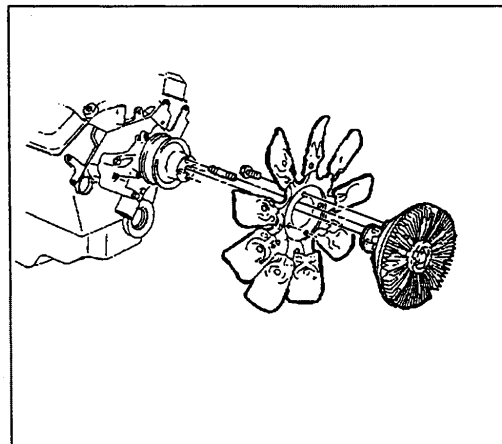
Tighten

Tighten the belt idler pulley bolt to 50 N.m (37 lb ft).



177620

7. Install the drive belt. Refer to *Drive Belt Replacement*.



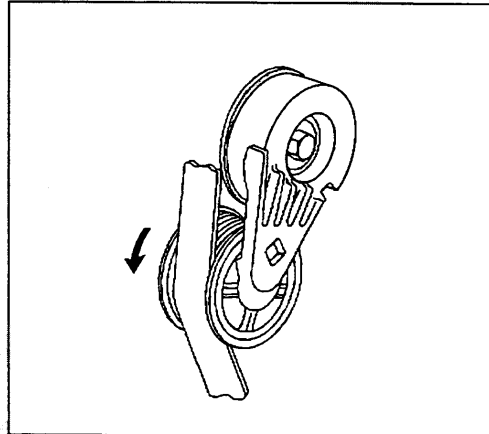
108015

8. Install the engine cooling fan. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)* in Engine Cooling.

SIE-ID - 358143

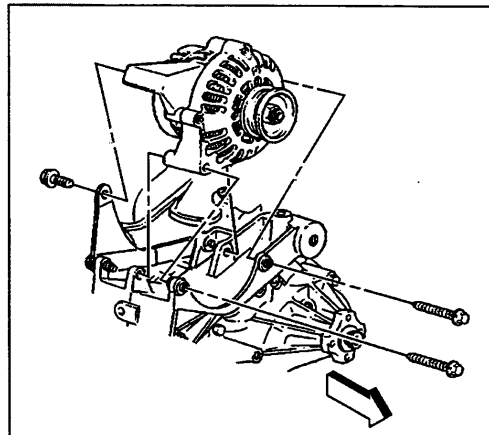
**Accessory Mounting Brackets
Replacement (Generator)****Removal Procedure**

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in engine electrical.
2. Remove the engine cooling fan. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)* in Engine Cooling.
3. Remove the drive belt. Refer to *Drive Belt Replacement*.

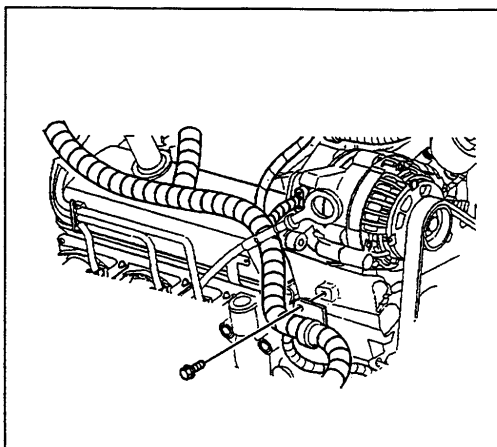


177620

4. Remove the generator. Refer to *Generator Replacement (Gasoline)* in Engine Electrical.

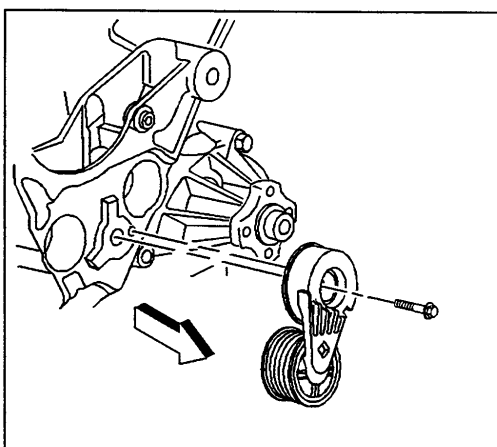


43033



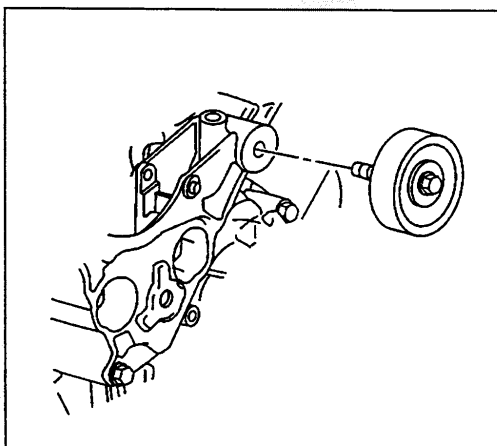
340790

5. Remove the wire harness bracket from the generator and drive belt tensioner bracket.



43854

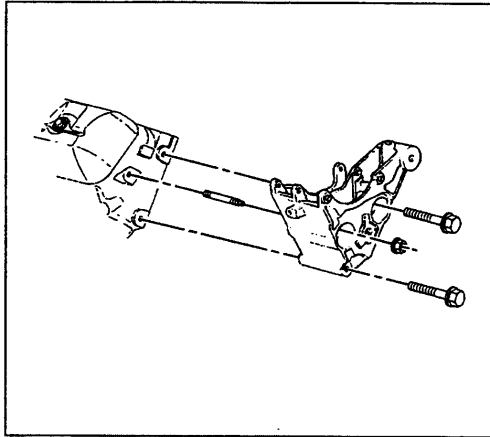
6. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.



310229

7. Remove the belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement*.

8. Remove the three bolts and nut holding the generator and drive belt tensioner to the engine.
9. Slide the accessory mounting bracket off of the stud.



196643

Installation Procedure

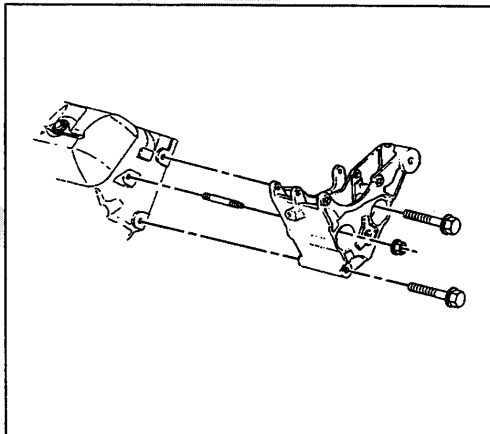
1. Slide the accessory mounting bracket on the stud.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the three bolts and the nut.

Tighten

Tighten the bolts and nut to 41 N·m (30 lb ft).

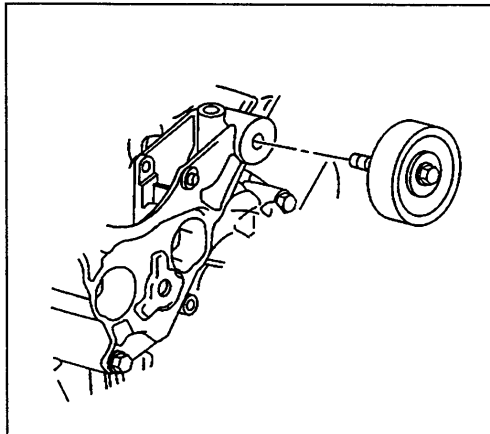


196643

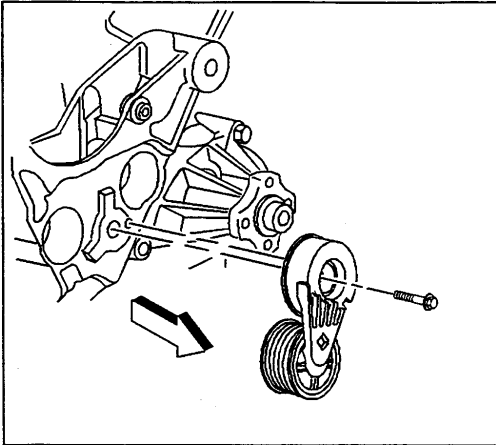
3. Install the belt idler pulley.

Tighten

Tighten the belt idler pulley bolt to 50 N·m (37 lb ft).



310229

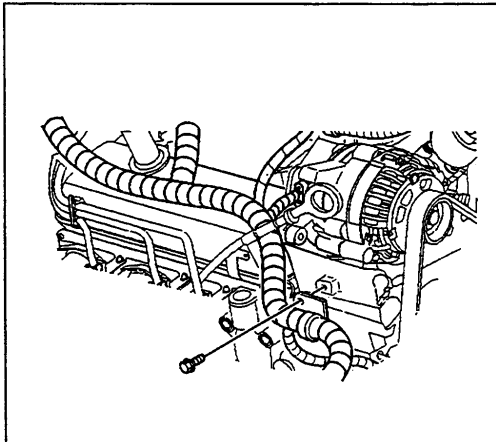


43854

4. Install the drive belt tensioner.

Tighten

Tighten the drive belt tensioner bolt to 50 N.m (37 lb ft).

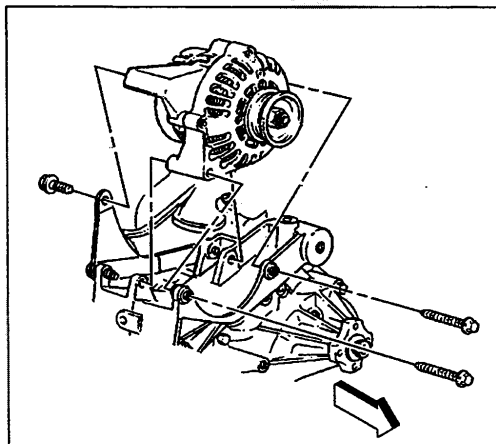


340790

5. Install the wire harness bracket to the generator and drive belt tensioner mounting bracket.

Tighten

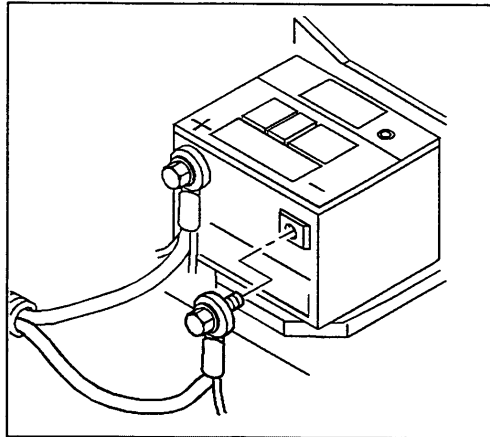
Tighten the bolt to 24 N.m (18 lb ft).



43033

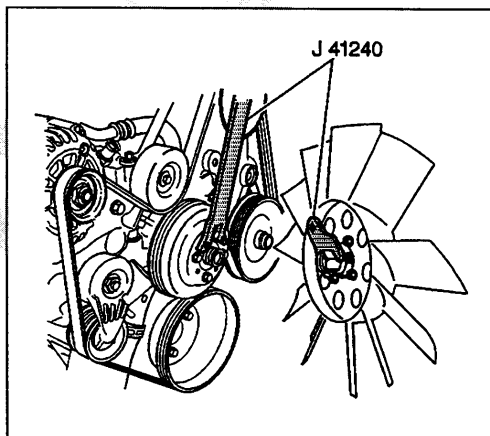
6. Install the generator. Refer to *Generator Replacement (Gasoline)* in Engine Electrical.
7. Install the drive belt. Refer to *Drive Belt Replacement*.

8. Connect the battery negative cable.



38205

9. Install the engine cooling fan. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)* in Engine Cooling.



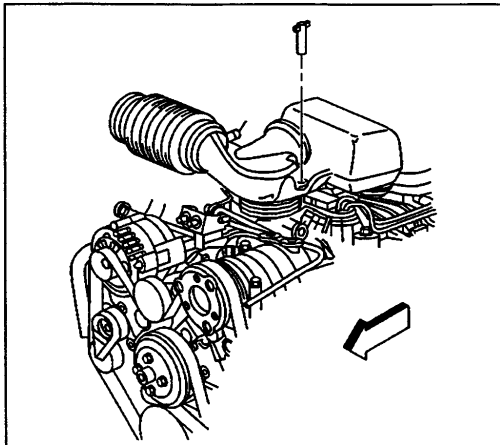
42910

S/E-ID - 332389

Intake Manifold Replacement (Lower)

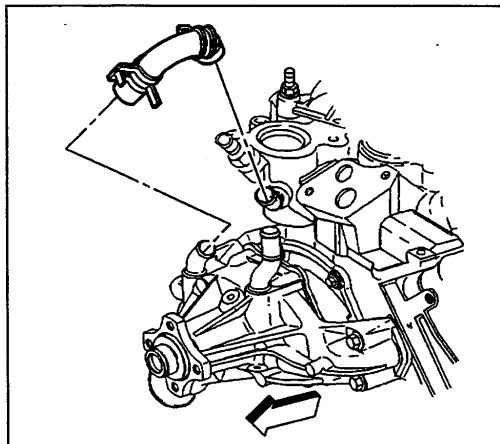
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System (ERROR - NOT IN CURRENT PSD)*.



308131

3. Remove the air cleaner assembly.

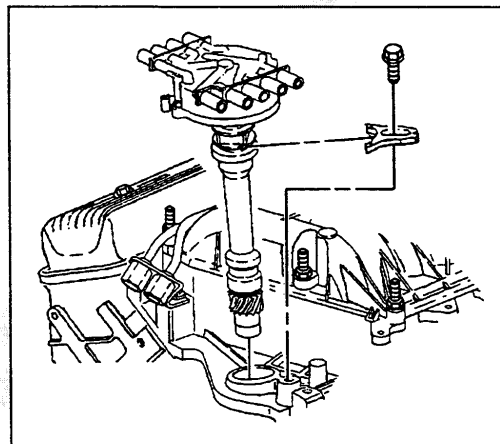


182853

4. Remove the following coolant hoses:

- Upper radiator hose. Refer to *Radiator Hose Replacement (5.0L)*.
- Both heater hoses. Refer to *Heater Hoses Replacement (Outlet Hose - 7.4L)* in Engine Cooling.
- Water pump inlet hose. Refer to *Hot Water Bypass Valve Replacement* in Engine Cooling.

5. Disconnect all electrical connectors and secure out of the way.

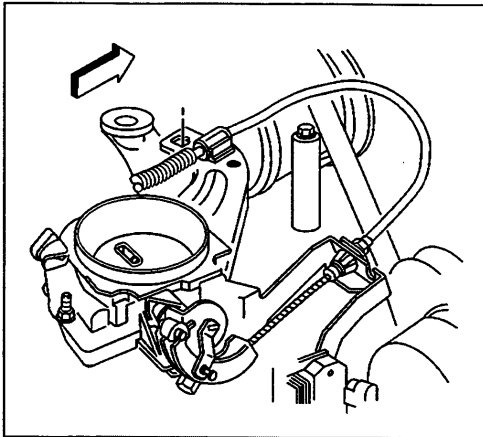


173208

6. Remove the distributor. Refer to *Distributor Replacement (5.0L, 5.7L)* in Engine Electrical.

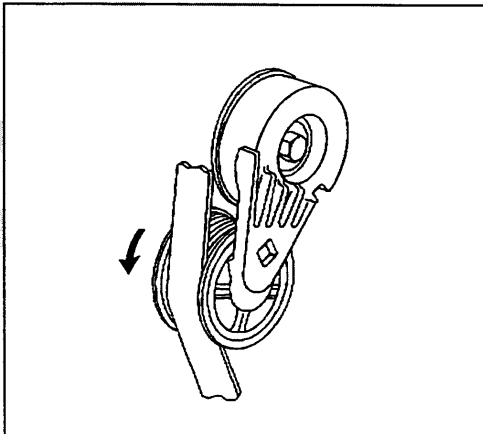
7. Use a twisting motion to remove the vacuum brake booster hose, if equipped.

8. Disconnect the accelerator control cable and the cruise control cable, if equipped. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.



216754

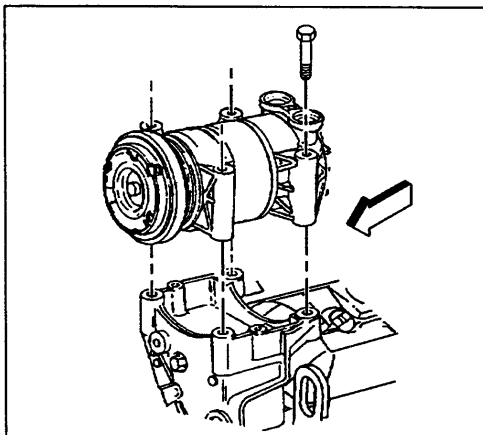
9. Remove the drive belt. Refer to *Drive Belt Replacement*.



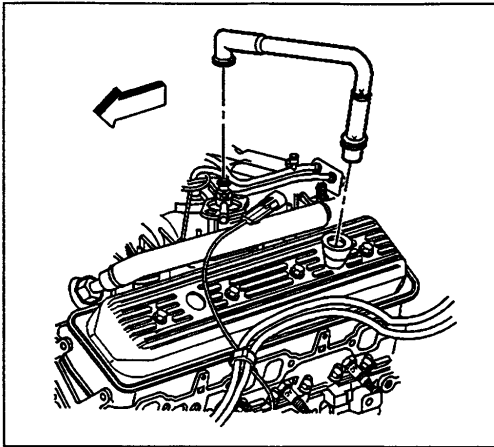
177620

Important: It is not necessary to discharge the A/C refrigerant.

10. Remove the air conditioning (A/C) compressor, if equipped, and set the A/C compressor aside. Refer to *Compressor Replacement (5.0L, 5.7L)*

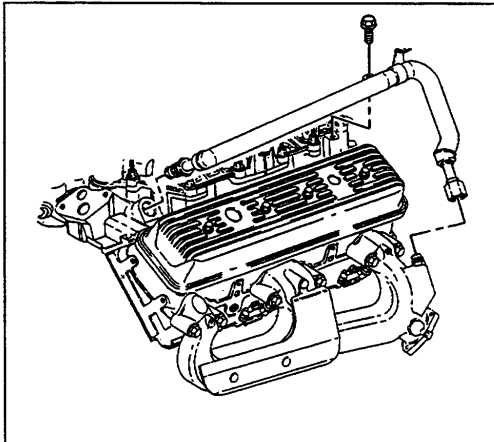


179249



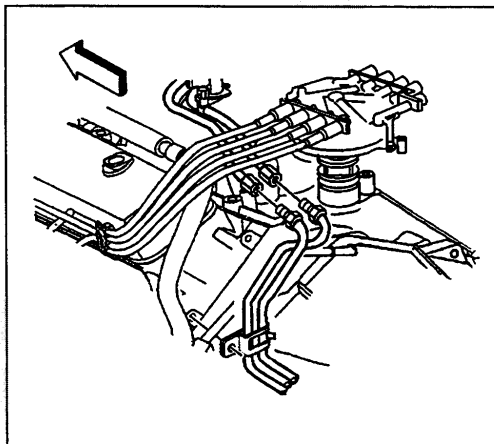
317197

11. Remove the PCV valve.



173206

12. Disconnect the exhaust gas recirculation (EGR) pipe from the bracket and the front of the intake manifold. Refer to Engine Controls.



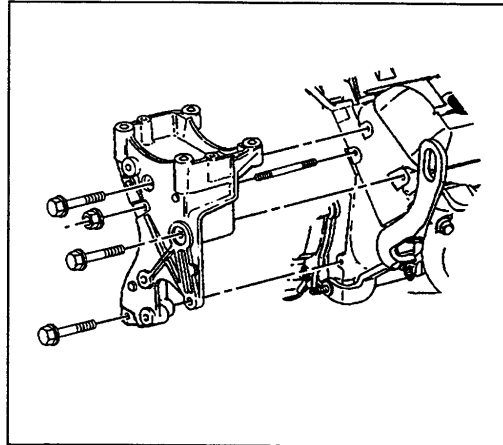
343625

13. Disconnect the fuel pipes from the rear of the intake manifold. Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.
14. Disconnect the electrical connector from the power steering pump.

Engine

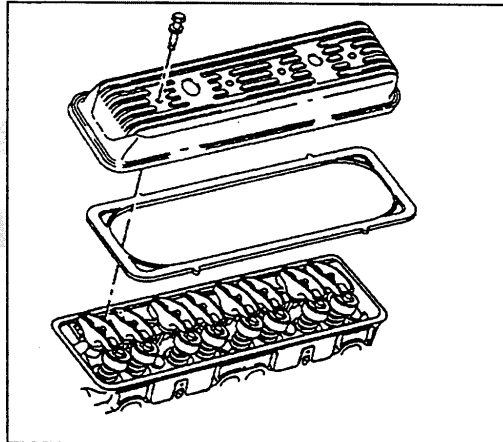
Engine Mechanical - 5.0L, 5.7L 6-53

15. Remove the power steering bracket using the following procedure:
 - 15.1. Remove the power steering pump pulley.
 - 15.2. Remove the nut, then the bolts.
 - 15.3. Remove two nuts from the back of the power steering pump.
 - 15.4. Slide the power steering bracket forward, with the power steering pump still attached.
16. Disconnect the wiring bracket from the rear of the right cylinder head.



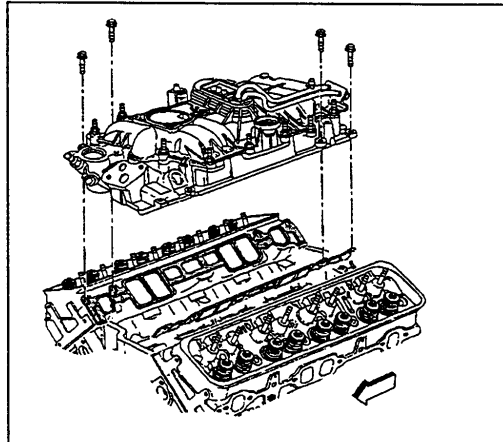
188295

17. Remove one valve rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement*.

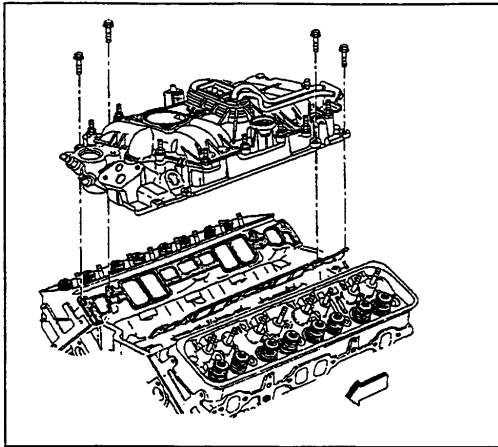


68709

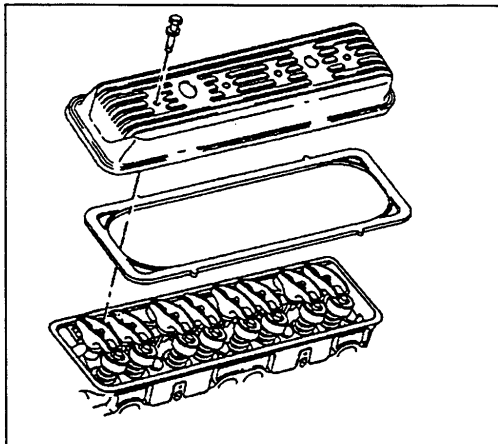
18. Remove the intake manifold bolts.
19. Remove the intake manifold. Refer to *Intake Manifold Removal*.
20. Clean all surfaces. Refer to *Intake Manifold Clean and Inspect*.



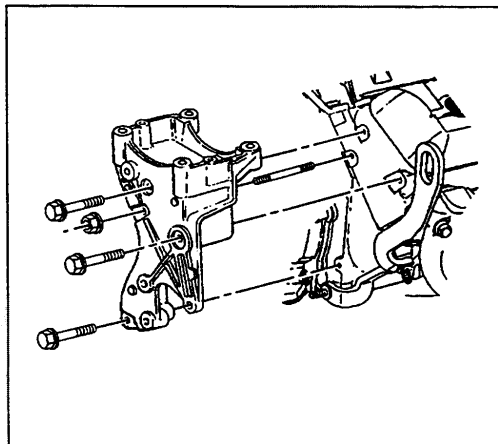
66456



66456



68709



188295

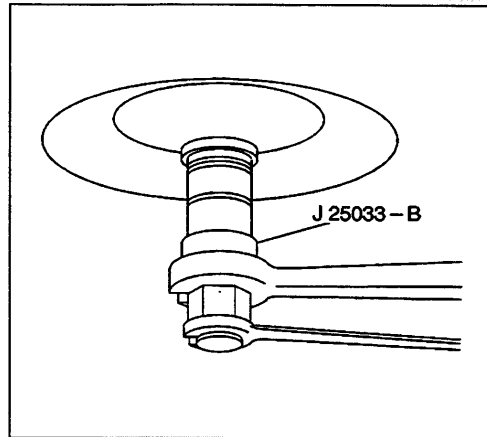
Installation Procedure

1. Install the intake manifold. Refer to *Intake Manifold Installation*.
2. Install the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Installation (Right)* and *Valve Rocker Arm Cover Installation (Left)*.
3. Install the power steering bracket using the following procedure:
 - 3.1. Install the power steering bracket onto the stud.
 - 3.2. Install the nut onto the stud finger tight.
 - 3.3. Install the three bolts finger tight.
 - 3.4. Install the two nuts to the back of the power steering pump.

Tighten

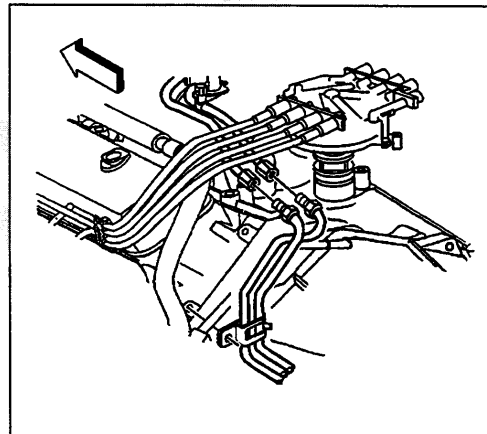
Tighten the nuts and the bolts to 41 N.m (30 lb ft).

4. Install the power steering pump pulley.
5. Connect the electrical connector to the power steering pump.



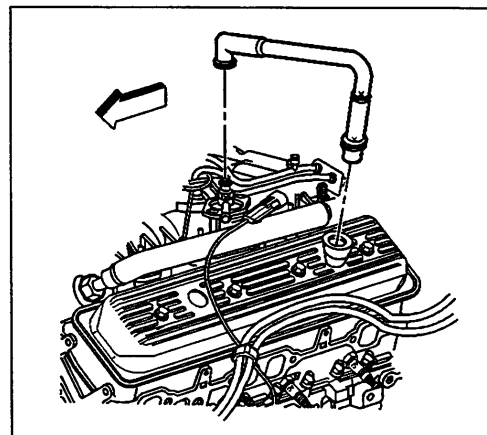
188373

6. Connect the fuel pipes to the rear of the intake manifold. Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.
7. Connect the wiring bracket to the rear of the right cylinder head.

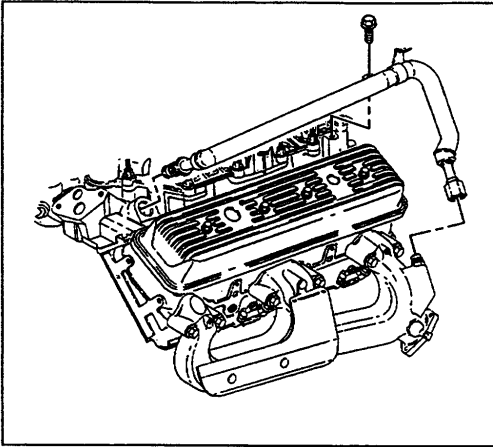


343625

8. Install the PCV valve.

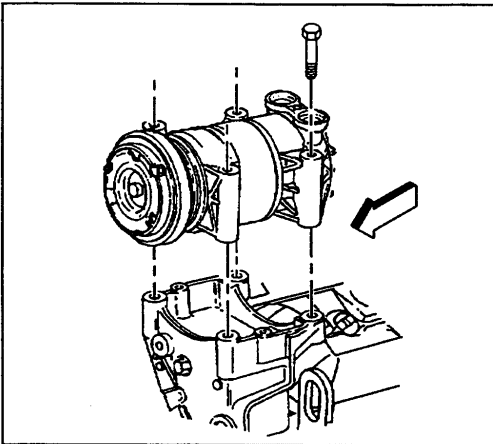


317197



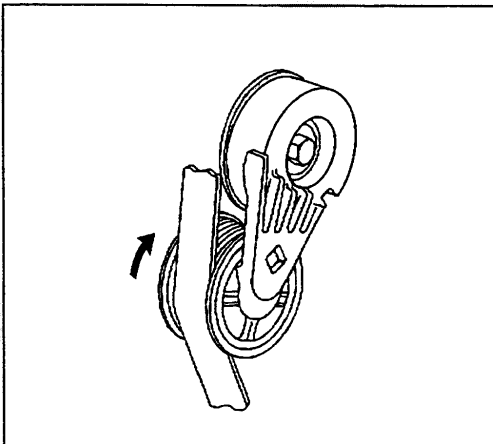
173206

9. Connect the exhaust gas recirculation (EGR) pipe to the bracket and the front of the intake manifold. Refer to Engine Controls.
10. Use a twisting motion to install the vacuum brake booster hose, if equipped.
11. Install AIR check valve (crossover) pipe, if equipped.



179249

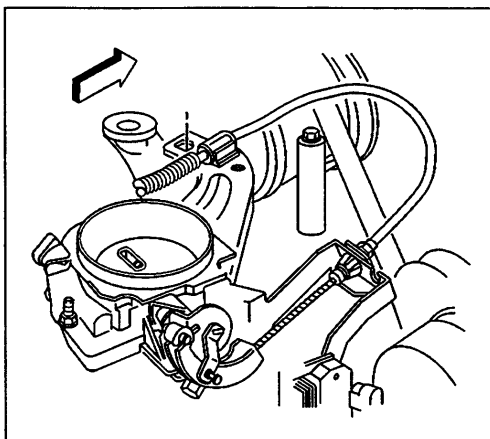
12. Install the air conditioning (A/C) compressor onto the power steering bracket.
13. Install the A/C compressor bolts.
Tighten
Tighten the bolts to 50 N·m (37 lb ft).



177622

14. Install the drive belt. Refer to *Drive Belt Replacement*.

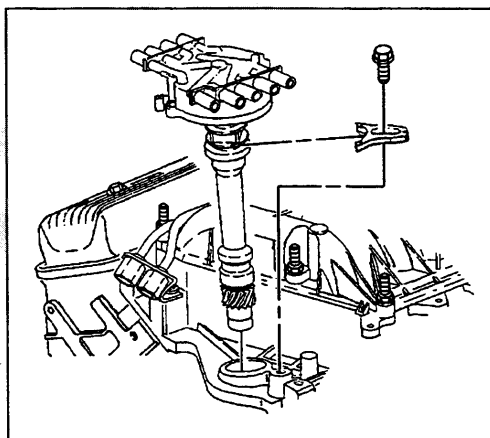
15. Connect the accelerator control cable and the cruise control cable, if equipped. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.



216754

16. Install the distributor. Refer to *Distributor Replacement (ERROR - NOT IN CURRENT PSD)*.

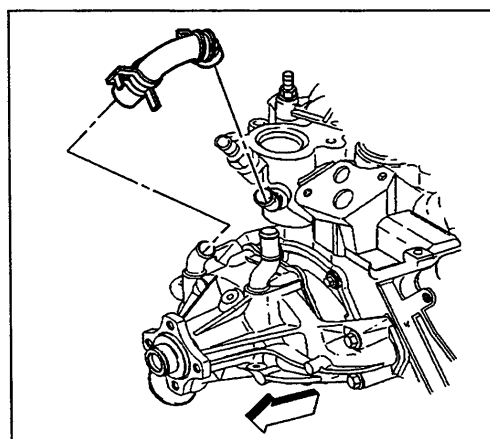
17. Connect all electrical connectors.



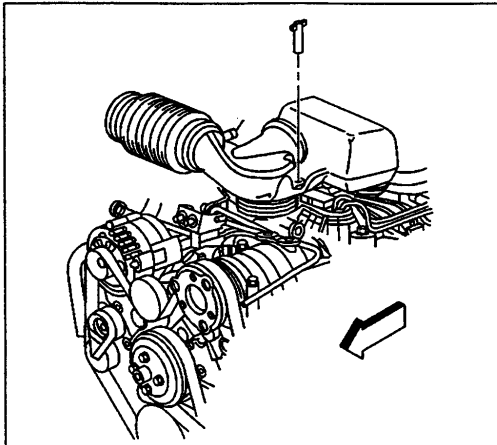
173208

18. Install the following coolant hoses.

- Upper radiator hose. Refer to *Radiator Hose Replacement (5.0L)* in engine cooling.
- Both heater hoses. Refer to *Heater Hoses Replacement (Outlet Hose - 7.4L)* in engine cooling.
- Water pump inlet. Refer to *Hot Water Bypass Valve Replacement* in engine cooling.



182853



308131

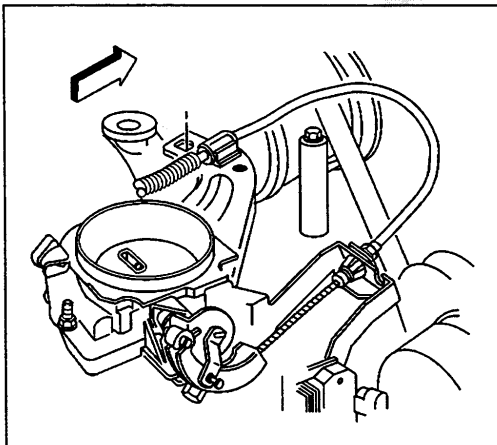
19. Install the air cleaner assembly.
20. Fill the cooling system with coolant. Refer to *Draining and Filling Cooling System (ERROR - NOT IN CURRENT PSD)*.
21. Connect the battery negative cable.

SIE-ID - 332395

Intake Manifold Replacement (Upper)

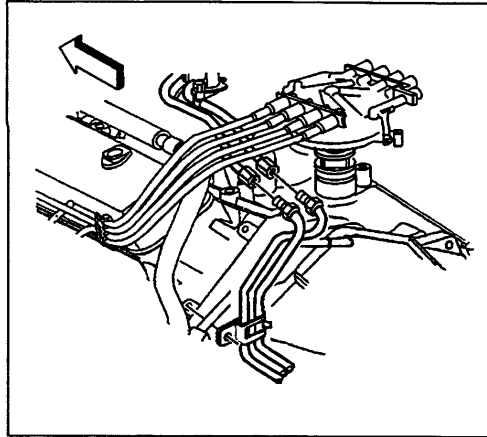
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.
2. Remove the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement* in Engine Controls.
3. Remove the vacuum brake booster hose, if equipped.
4. Disconnect the accelerator control and cruise control cables (if equipped). Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
5. Remove the accelerator control cable bracket and set it aside.
6. Remove the following electrical connectors:
 - The SCPI injector harness connector
 - The EVAP canister purge solenoid valve
 - The ignition coil
 - The ignition control module (ICM)
 - The generator
 - The idle air control (IAC) motor
 - The throttle position (TP) sensor
 - The oxygen (O²) sensor
 - The exhaust gas recirculation (EGR) valve
 - The engine coolant temperature (ECT) sensor
 - The engine oil pressure sensor



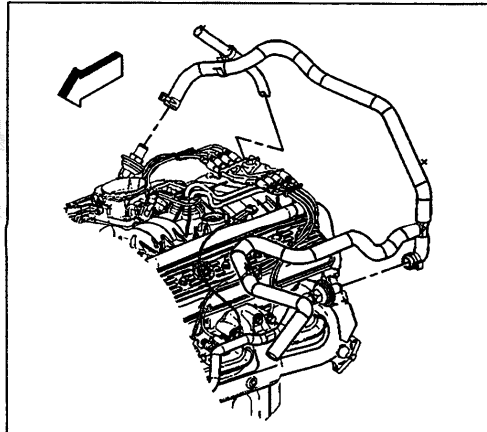
216754

7. Disconnect the fuel pipes from the fuel pipes. Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.



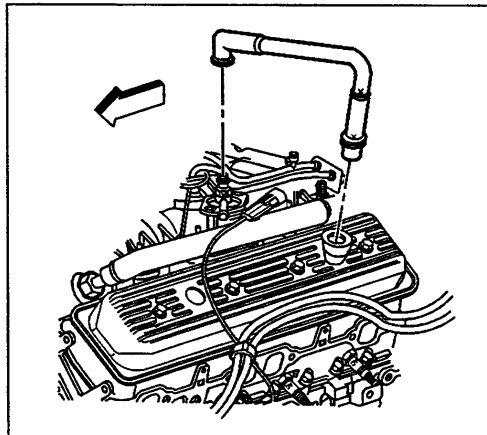
343625

8. Remove the AIR check valve (crossover) pipe, if equipped.
9. Remove the distributor cap and reposition the distributor cap out of the way.

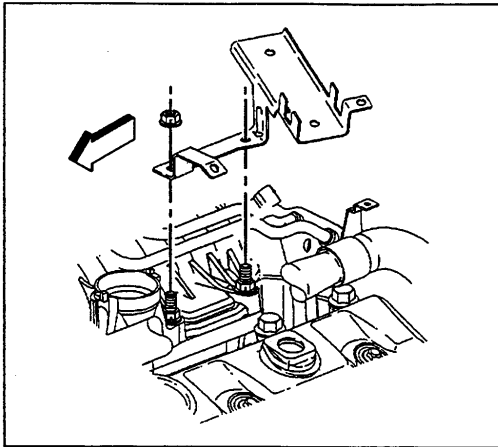


341228

10. Remove the PCV valve hose assembly.

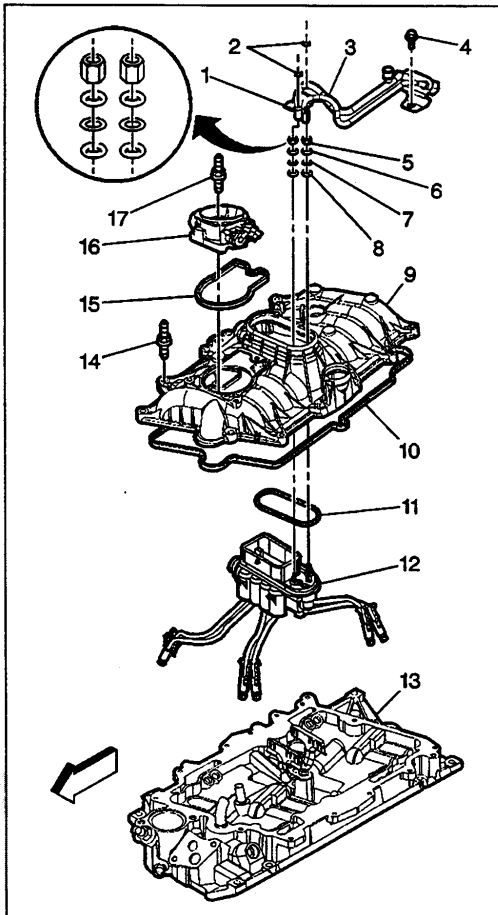


317197



179250

11. Remove the engine wiring harness bracket from the manifold.
12. Remove the EVAP canister purge solenoid valve.

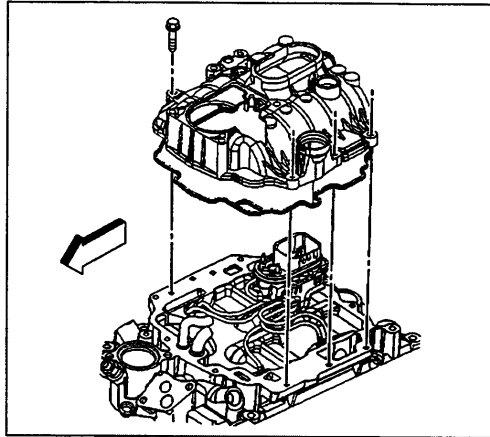


66929

13. Remove the studs holding the upper intake manifold to the lower intake manifold.
14. Remove the upper intake manifold. Refer to *Intake Manifold Disassemble*.
15. Clean all the surfaces. Refer to *Intake Manifold Clean and Inspect*.

Installation Procedure

1. Install the upper intake manifold. Refer to *Intake Manifold Assemble*.
2. Install the EVAP canister purge solenoid valve.



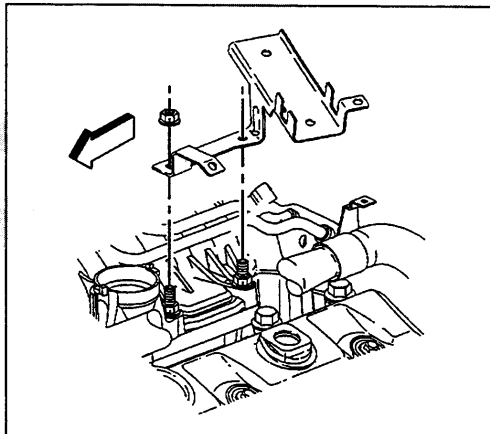
31649

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the engine wiring harness bracket to the upper intake manifold.

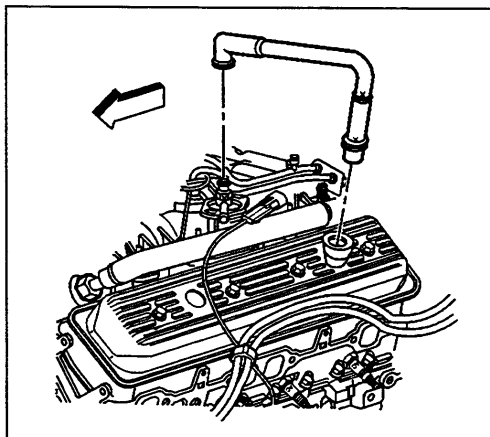
Tighten

Tighten the nut to 12 N·m (106 lb in).

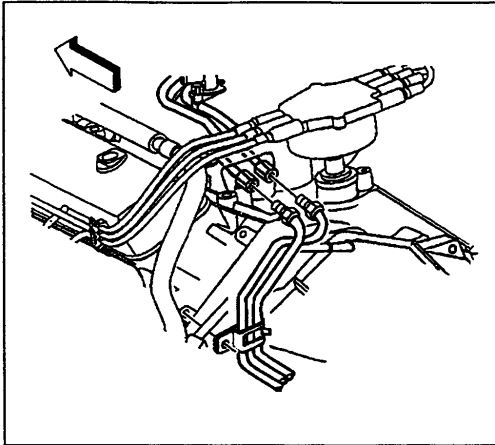


179250

4. Install the PCV valve hose assembly.
5. Install the distributor cap. Refer to *Distributor Replacement (5.0L, 5.7L)* in Engine Electrical.

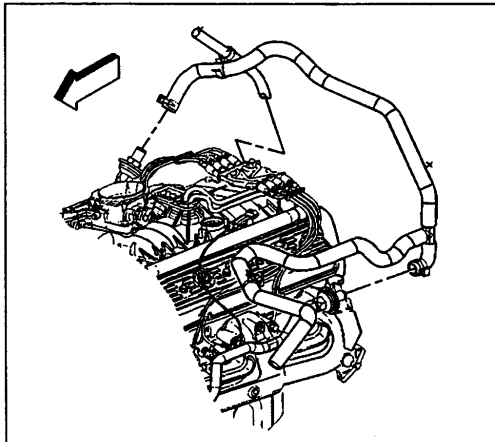


317197



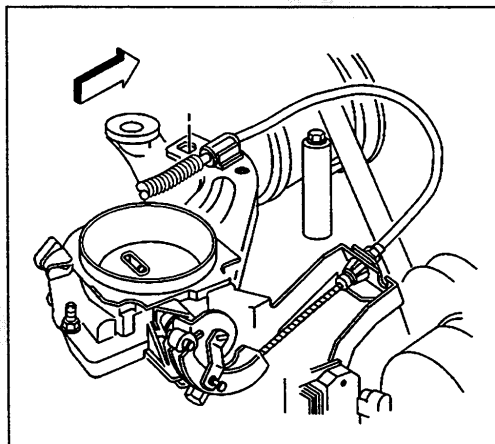
172997

6. Connect the fuel pipes to the rear of the engine. Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.



341228

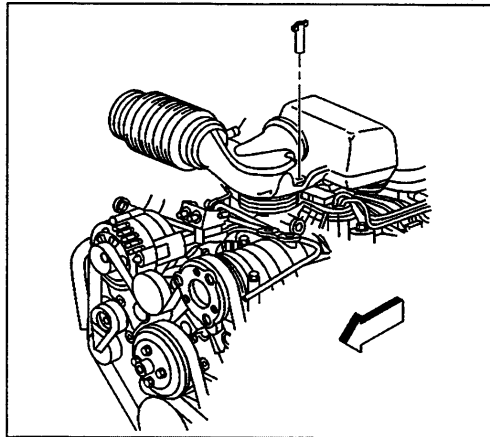
7. Install the AIR check valve (crossover) pipe, if so equipped.
8. Connect the electrical connectors.
9. Install the accelerator control cable bracket.



216754

10. Connect the accelerator control cable and the cruise control cable, if equipped. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.

11. Install the vacuum brake booster hose, if equipped.
12. Install the air cleaner assembly.
13. Connect the battery negative cable.



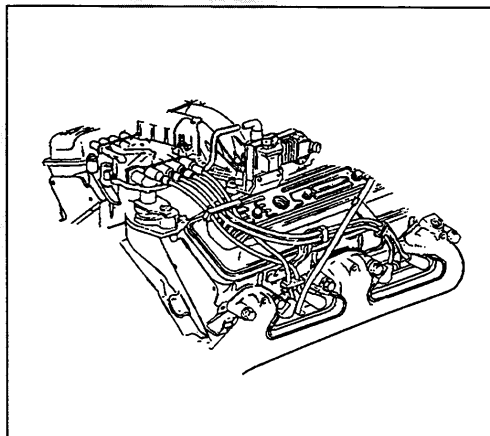
308131

SIE-ID = 332408

Valve Rocker Arm Cover Replacement

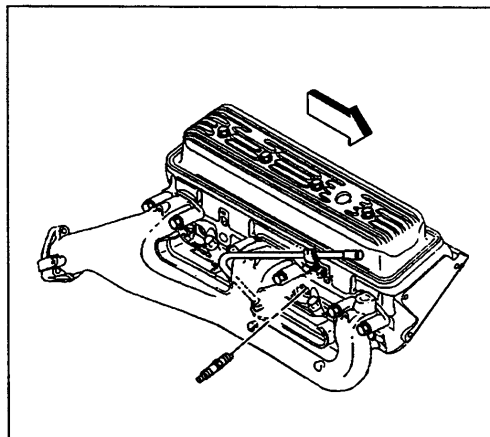
Removal Procedure

1. Disconnect the spark plug wires from the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.
2. Disconnect the wiring harness from the clips, and move the harness aside.
3. Remove the air cleaner intake duct for access to the right valve rocker arm cover. Refer to Air Cleaner Assembly in Engine Controls.

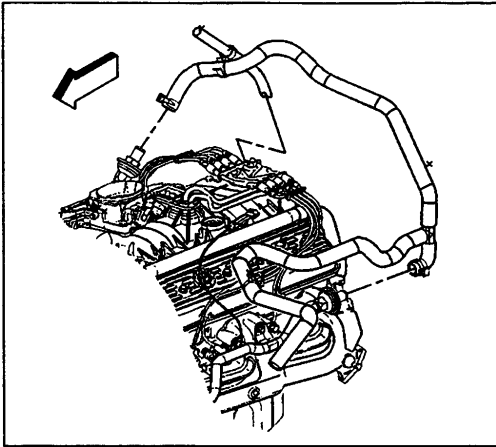


176070

4. Remove the bolts and oil level indicator tube bracket. Refer to *Oil Level Indicator and Tube Replacement*.

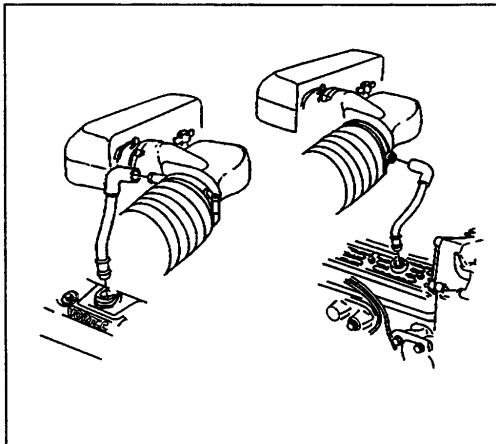


345189



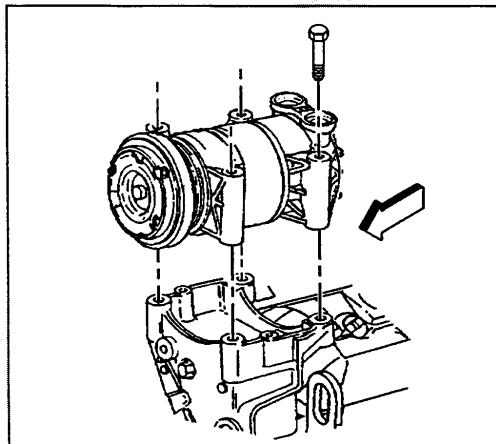
341228

5. Remove the AIR check valve (crossover), if so equipped.



173191

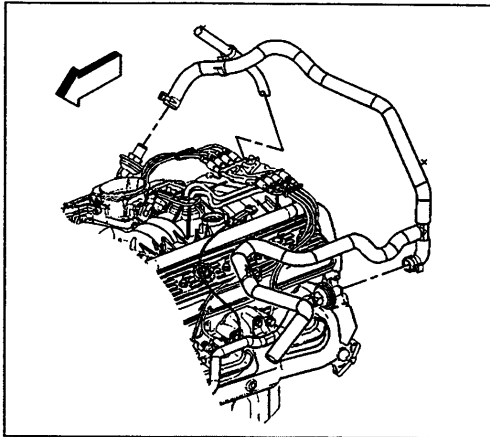
6. Remove the PCV tube.



179249

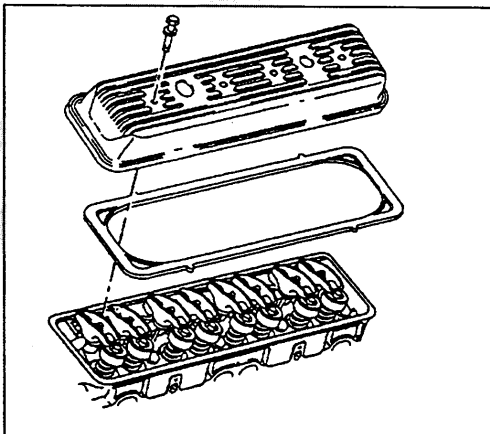
7. Remove the following components for access to the left valve rocker arm cover:
 - 7.1. The air conditioning (A/C) compressor, if equipped, and lay the A/C compressor aside. Refer to *Compressor Replacement* (5.0L, 5.7L).
 - 7.2. The EGR valve inlet pipe
 - 7.3. The PCV and the hose
 - 7.4. The vacuum brake booster pipe, if equipped, and move it aside

8. Remove the AIR check valve (crossover) pipe, if so equipped.



341228

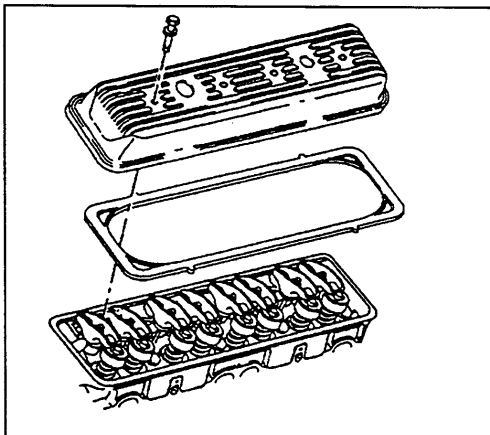
9. Remove the valve rocker arm cover and the gasket. Refer to *Valve Rocker Arm Cover Removal (Right)* and *Valve Rocker Arm Cover Installation (Left)*.
10. Clean all traces of old gasket from the valve rocker arm cover and the cylinder head. Refer to *Valve Rocker Arm Cover Clean and Inspect*.



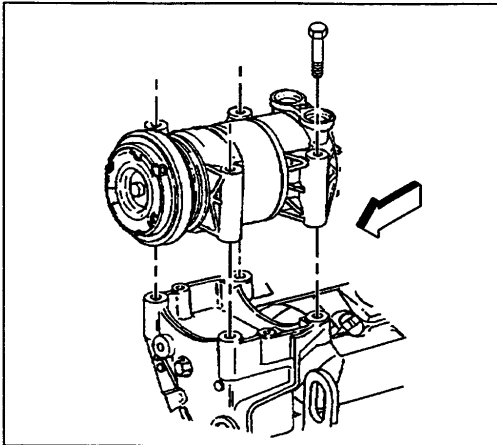
68709

Installation Procedure

1. Install the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Installation (Left)*.

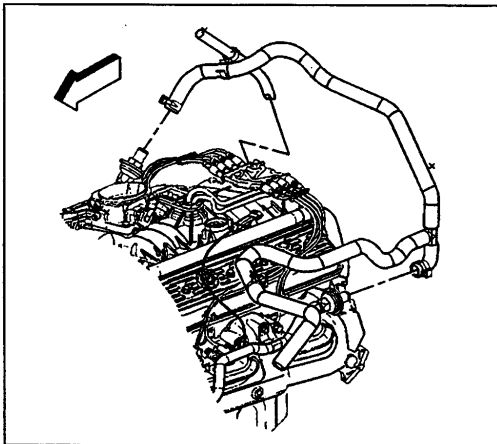


68709



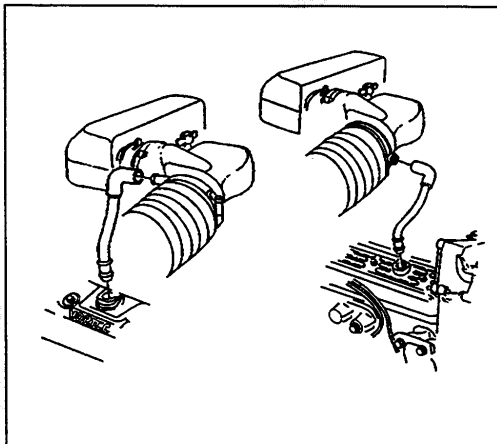
179249

2. Install the components as follows for the left valve rocker arm cover:
 - 2.1. The air conditioning compressor. Refer to *Compressor Replacement (5.0L, 5.7L)*.
 - 2.2. The EGR valve pipe. Refer to Engine Controls.
 - 2.3. The PCV and the hose
 - 2.4. The vacuum brake booster pipe



341228

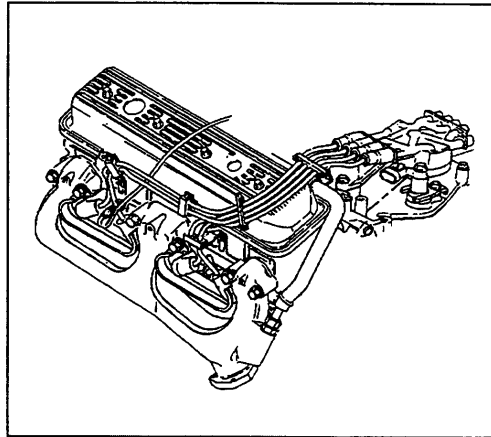
3. The AIR check valve (crossover) pipe, if equipped.



173191

4. Install the components as follows for the right valve rocker arm cover:
 - 4.1. The air cleaner intake duct.
 - 4.2. The crankcase ventilation hose.
 - 4.3. The oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.
5. Install the wiring harnesses to the valve rocker arm cover clips.

6. Install the spark plug wires. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.



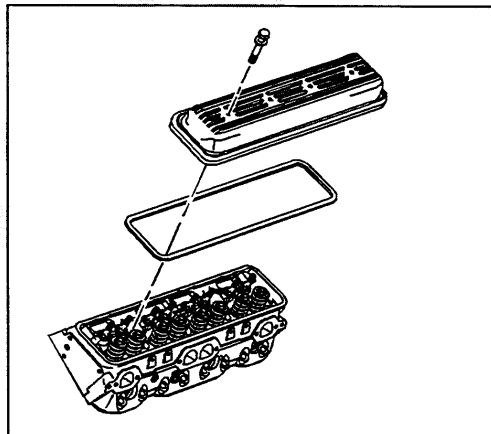
176067

SIE-ID = 332411

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

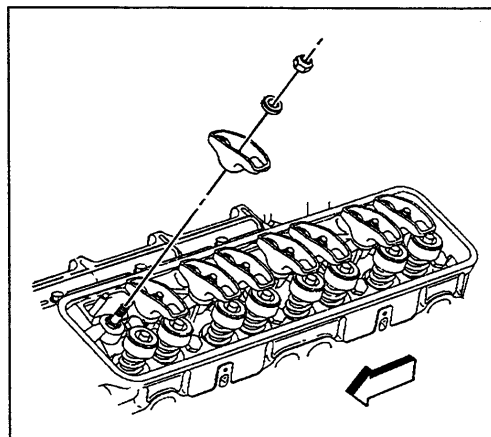
1. Remove the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement*.



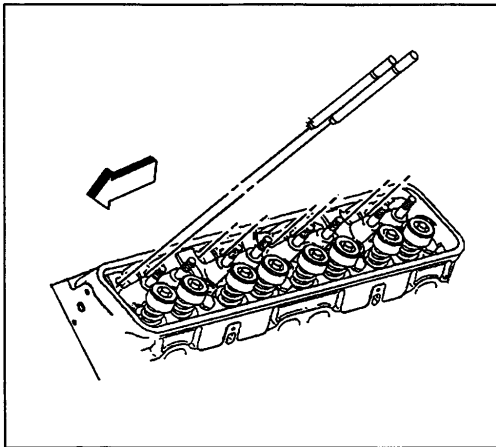
39119

Important: Store used components in order so that they can be reassembled in the same location.

2. Remove the valve rocker arm nut.
 - 2.1. If only the valve pushrod is being replaced, back the valve rocker arm nut off until the valve rocker arm can rotate away from the valve pushrod.
 - 2.2. Then remove the valve pushrod.
3. Remove the valve rocker arm with the valve rocker arm ball.



343916

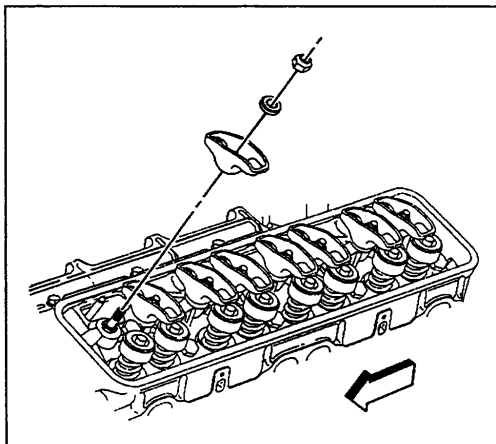


343915

4. Remove the valve pushrod.
5. Clean and inspect all parts. Refer to *Valve Rocker Arm and Push Rods Clean and Inspect*.

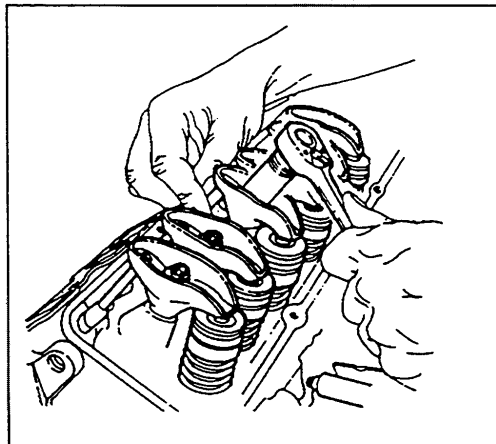
Installation Procedure

1. Install the valve pushrod. Refer to *Valve Rocker Arm and Push Rod Installation*.



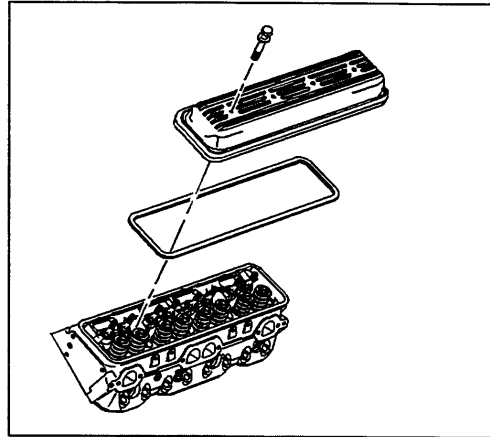
343916

2. Adjust the valve lash. Refer to *Valve Lash Adjustment*.



22759

3. Install the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement*.



39119

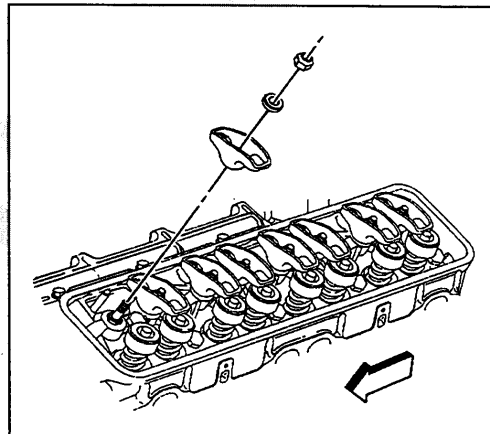
SIE-ID = 332413

Valve Stem Oil Seal and Valve Spring Replacement

Removal Procedure

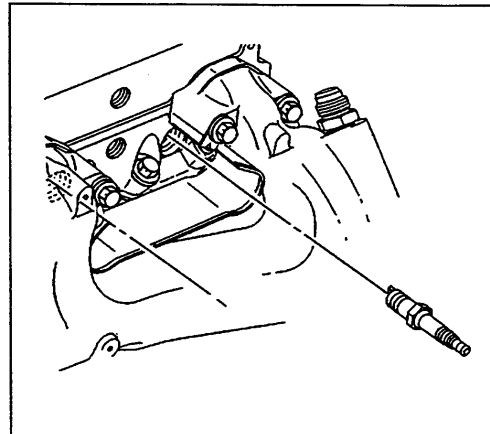
Tools Required

- J 22794 Spark Plug Port Adapter
 - J 38606 Valve Spring Compressor
 - J 5892-D Valve Spring Compressor
1. Remove the valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.

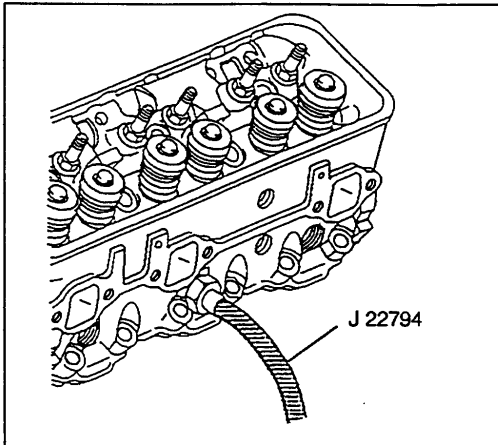


343916

2. Remove the spark plugs. Refer to *Spark Plug Replacement*.



172979

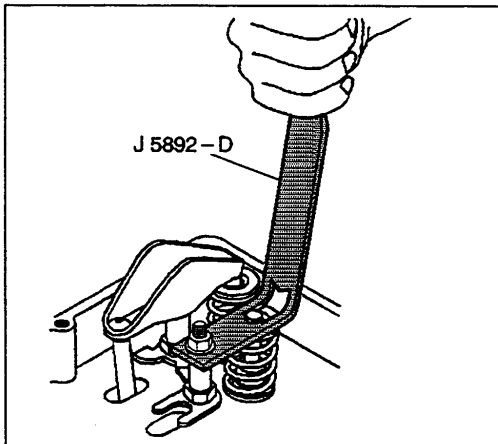


65039

3. Install the J 22794 into the spark plug hole.

Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

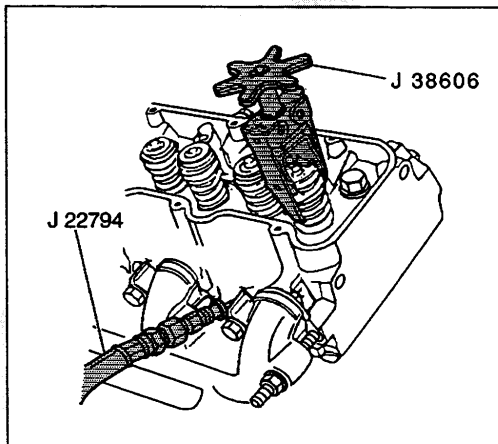
4. Apply compressed air in order to hold the valves in place.



1964

5. Install the valve rocker arm nut.

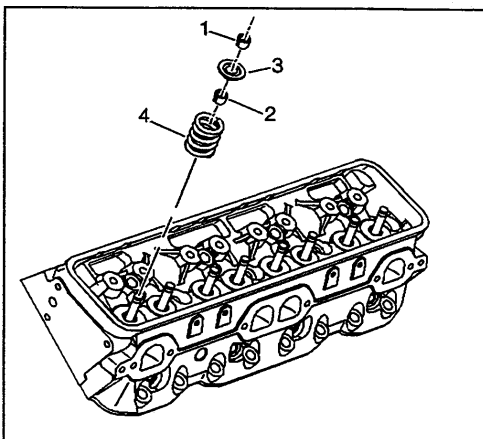
6. Use the J 5892-D in order to compress the valve spring.



218211

7. Use the J 38606 if clearance does not permit use of J 5892-D.

8. Remove the valve stem keys (1).
9. Carefully release the valve spring tension.
10. Remove the *J 5892-D* or the *J 38606*.
11. Remove the valve spring cap and valve spring (4).
12. Remove the valve stem oil seal (2).



69538

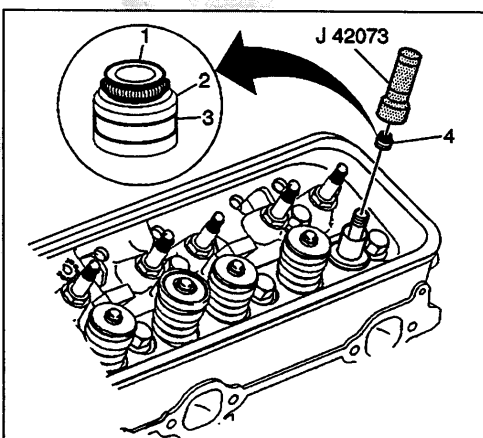
Installation Procedure

Tools Required

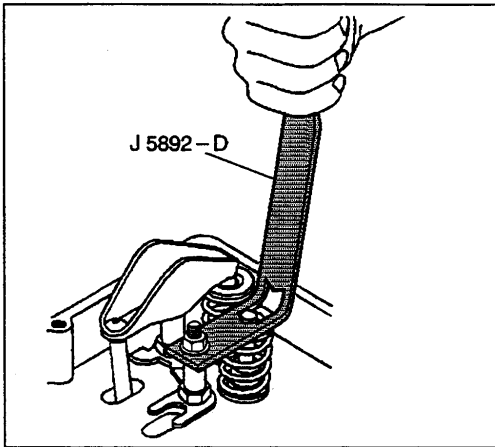
- *J 22794* Spark Plug Port Adapter
- *J 38606* Valve Spring Compressor
- *J 5892-D* Valve Spring Compressor
- *J 42073* Valve Stem Seal Installer

Important: The exhaust valve oil seal has the letters EX (1) molded into the top of the seal. The seal material is brown in color (2) with a white stripe (3) painted on the outside diameter of the seal.

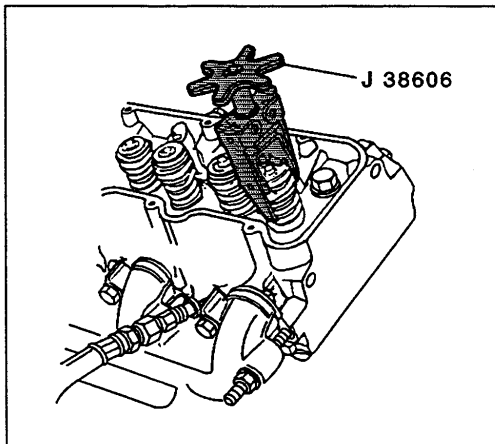
1. Select the proper valve stem oil seal for the specific valve guide.
2. Lubricate the valve stem oil seal and guide with clean engine oil.
The exhaust and intake valve seals are not interchangeable.
3. Assemble the valve stem oil seal onto the valve guide using the *J 42073* and a hammer.
Install the oil seal onto the valve guide until the installation tool bottoms against the valve spring seat.
4. Install the valve spring.



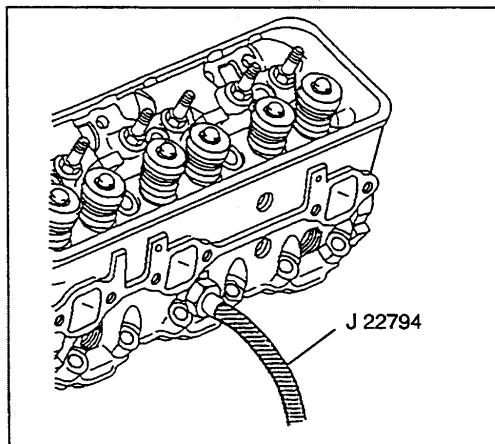
200320



1964



31730



65039

5. Use the *J 5892-D* in order to compress the valve spring.

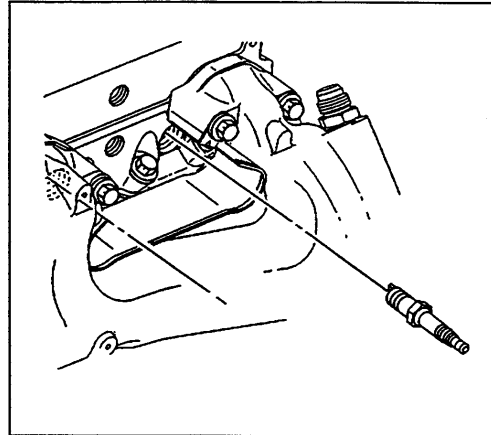
6. Use the *J 38606* if clearance does not permit use of *J 5892-D*.
7. Install the valve stem keys (1).
Use grease in order to hold the valve stem keys in place.
8. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.

9. Remove the *J 5892-D* or *J 38606* and the *J 22794*.

Engine

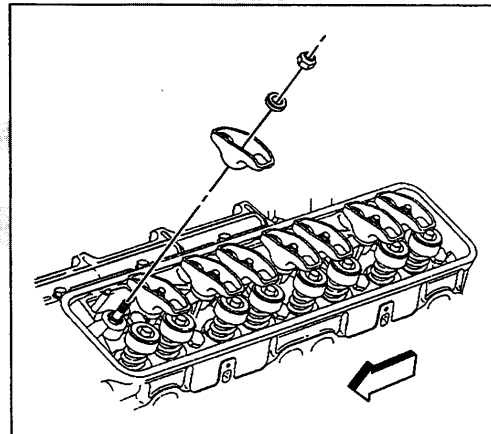
Engine Mechanical - 5.0L, 5.7L 6-73

10. Install the spark plugs. Refer to *Spark Plug Replacement*.



172979

11. Install the valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.



343916

SIE-ID - 332418

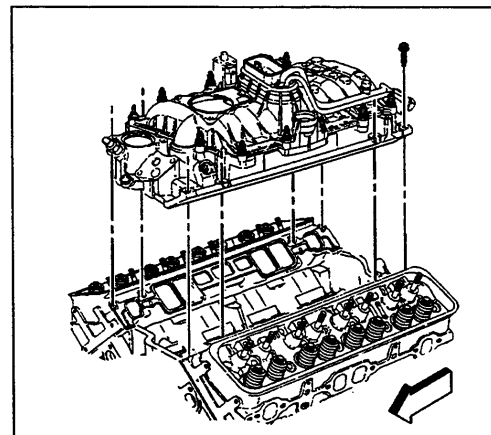
Valve Lifter Replacement

Removal Procedure

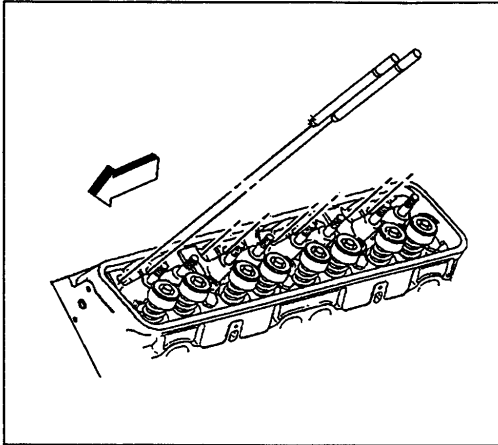
Tools Required

J 3049-A Valve Lifter Remover

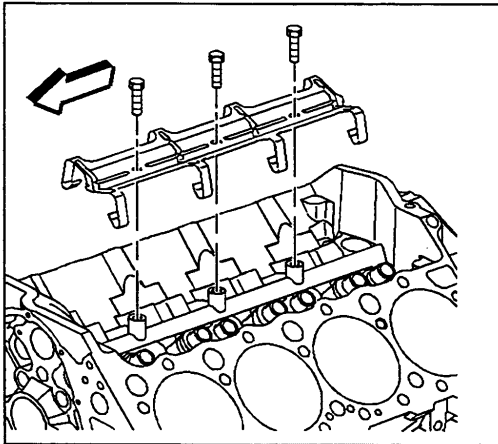
1. Remove the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



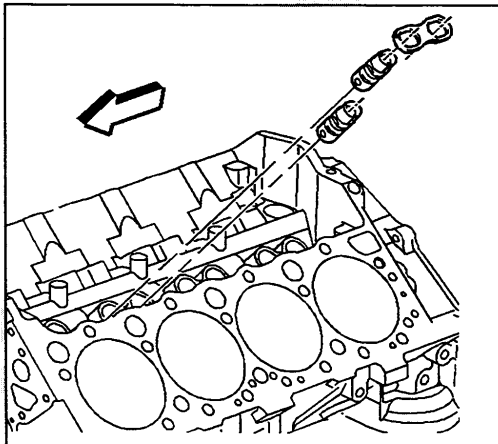
343948



343915



11508



11509

Important: The valve lifters and valve guides must be installed in the same location from which the valve lifter and valve guides were removed.

2. Remove the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*

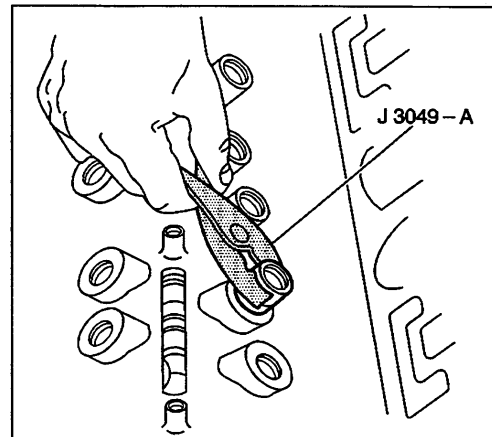
3. Remove the valve lifter guide retainer.

4. Remove the valve lifter guides.

Important: Place the valve lifters in a rack in the upright position in order to maintain the oil inside the valve lifter.

5. Place the lifters and guides in an organizer rack.

6. A stuck valve lifter can be removed using the J 3049-A.
Refer to *Cylinder Head Replacement* to obtain access to the valve lifter.
7. Inspect the valve lifter. Refer to *Valve Lifters and Guides Clean and Inspect*.

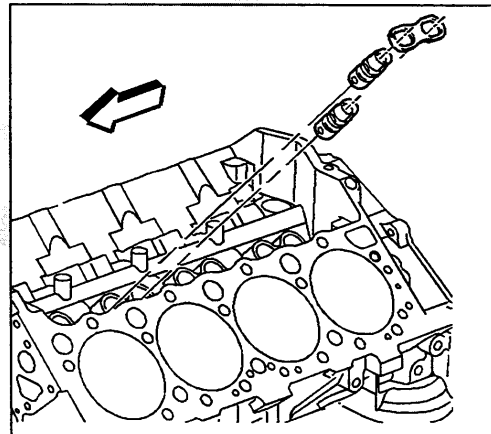


31350

Installation Procedure

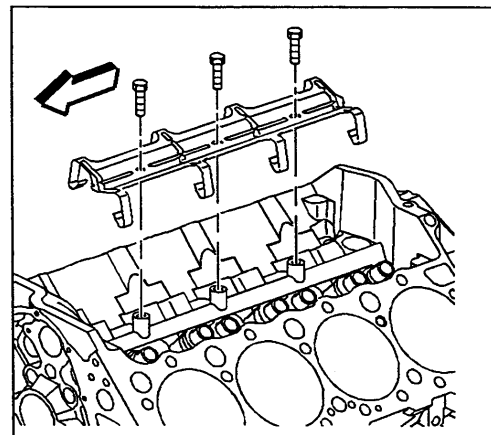
Important:

- When the new valve lifters or a new engine camshaft is installed, change the engine oil and the oil filter. Refer to *Engine Oil and Oil Filter Replacement*.
 - Add Engine Oil Supplement GM P/N 1051396 or the equivalent to the engine oil.
 - Replace the valve lifters as required when a new engine camshaft is installed.
1. Install the valve lifters one at a time.

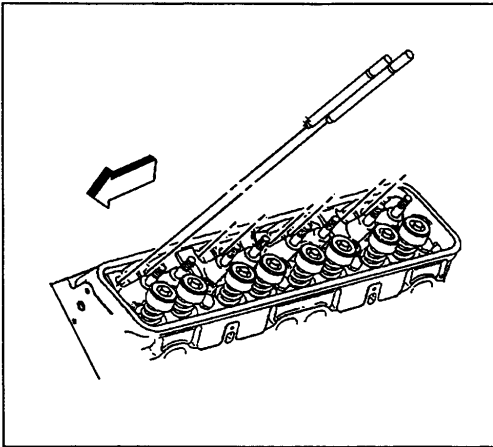


11509

2. Install the valve lifter guide retainer. Refer to *Valve Lifter Installation*.

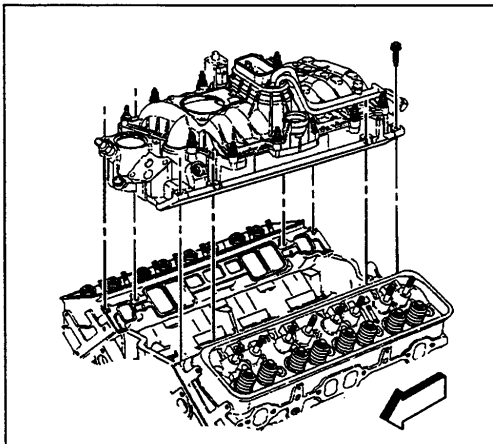


11508



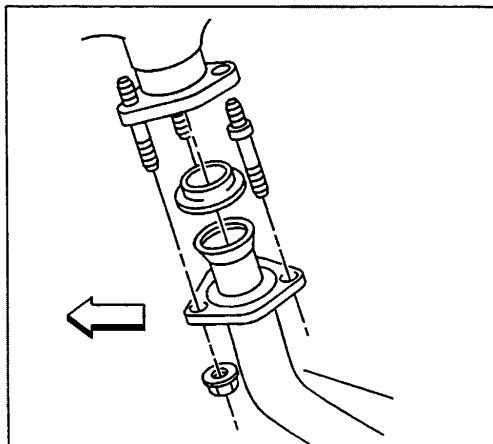
343915

3. Install the pushrods. Refer to *Valve Rocker Arm and Push Rod Installation*.



343948

4. Install the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



42940

SIE-ID = 332420

Exhaust Manifold Replacement (Left Side)

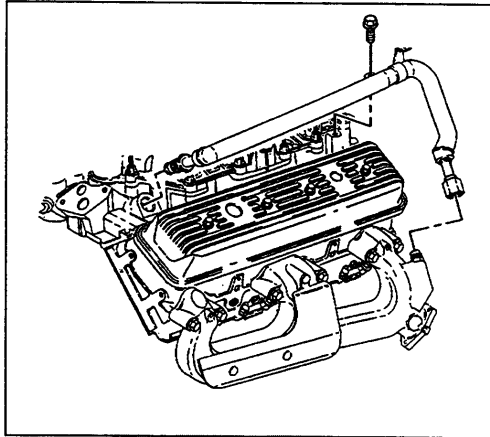
Removal Procedure

1. Remove the exhaust pipe from the exhaust manifold.
2. Disconnect the oxygen sensor electrical connector.

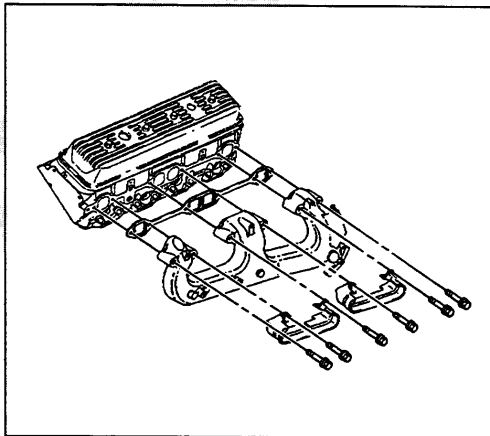
Engine

Engine Mechanical - 5.0L, 5.7L 6-77

3. Disconnect the EGR valve pipe from the exhaust manifold.

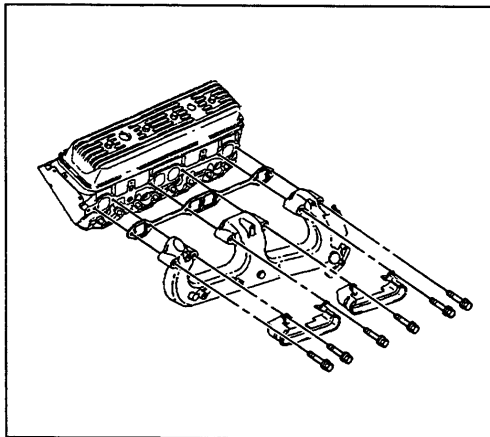


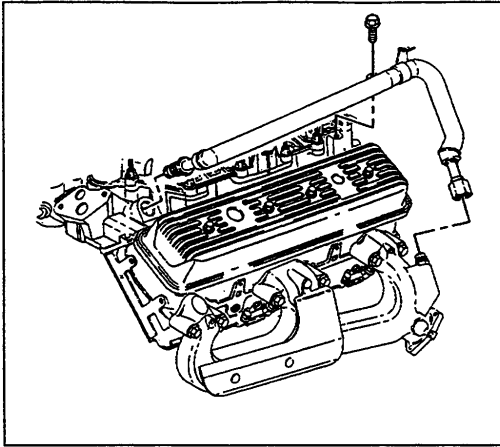
4. Remove the exhaust manifold bolts.
5. Remove the exhaust manifold. Refer to *Exhaust Manifold Removal (Left)*.
6. Clean all sealing surfaces. Refer to *Exhaust Manifold Clean and Inspect*.



Installation Procedure

1. Install the exhaust manifold. Refer to *Exhaust Manifold Installation (Left)*.





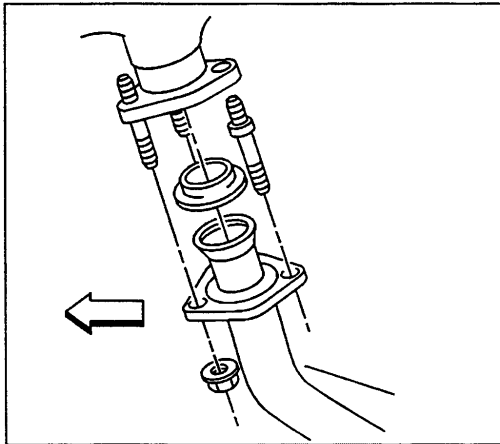
173206

Caution: Refer to *Battery Disconnect Caution in Cautions and Notices*.

2. Connect the EGR valve pipe to the exhaust manifold.

Tighten

Tighten the EGR valve pipe nut to 30 N·m (22 lb ft).



42940

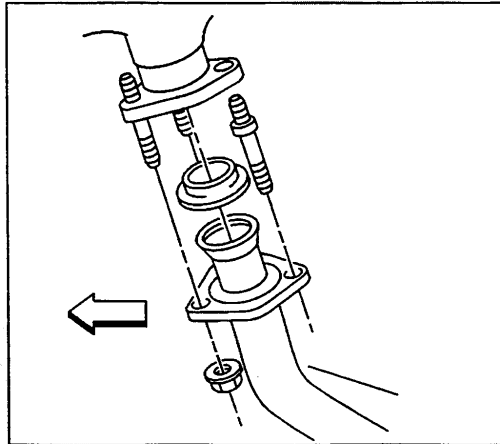
3. Install the exhaust pipe to the exhaust manifold. Refer to *Exhaust Manifold Pipe Replacement (Diesel)* in Engine Exhaust.
4. Connect the oxygen sensor electrical connector.

SIE-ID = 332421

Exhaust Manifold Replacement (Right Side)

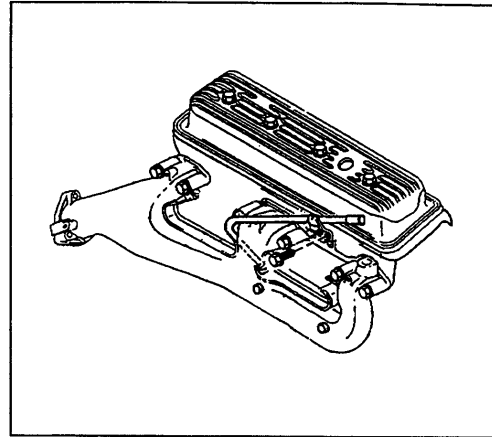
Removal Procedure

1. Remove the exhaust pipe from the exhaust manifold. Refer to *Exhaust Manifold Pipe Replacement (Diesel)* in Engine Exhaust.
2. Disconnect the oxygen sensor electrical connector.



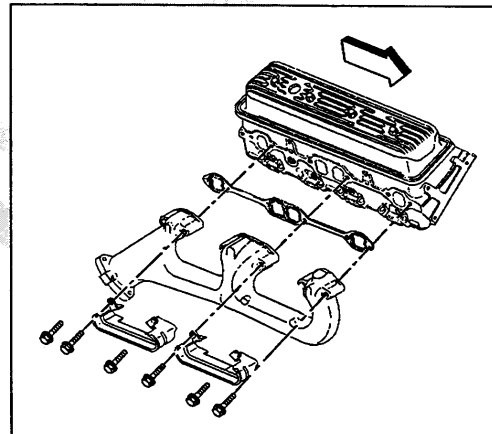
42940

3. Remove the air cleaner assembly.
4. Remove the bolt for the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.



173203

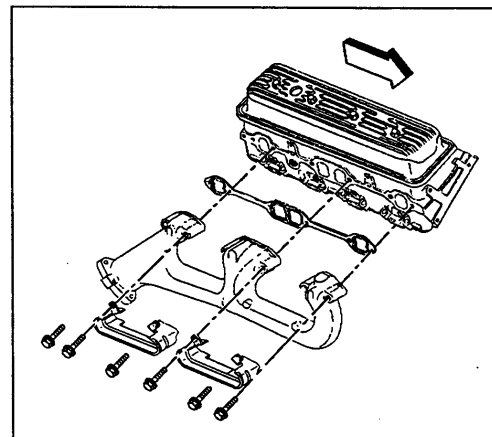
5. Remove the exhaust manifold bolts.
6. Remove the exhaust manifold. Refer to *Exhaust Manifold Removal (Right)*.
7. Clean all sealing surfaces. Refer to *Exhaust Manifold Clean and Inspect*.



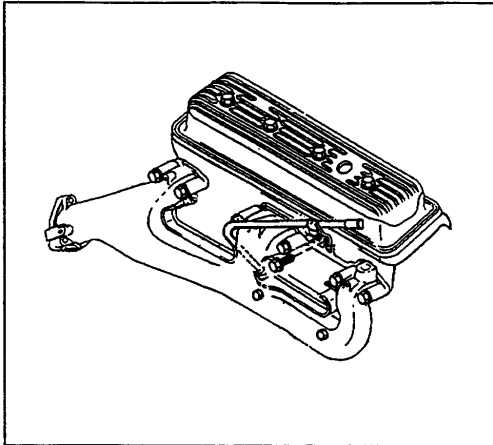
69032

Installation Procedure

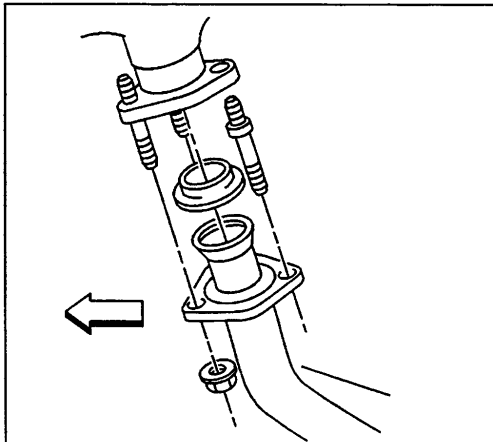
1. Install the exhaust manifold. Refer to *Exhaust Manifold Removal (Right)*.



69032



173203



42940

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.

Tighten

Tighten the bolt to 12 N.m (106 lb in).

3. Install the air cleaner assembly.

4. Install the exhaust pipe to the exhaust manifold. Refer to *Exhaust Manifold Pipe Replacement (Diesel)* in Engine Exhaust.
5. Connect the oxygen sensor electrical connector.

SIE-ID = 332428

Cylinder Head Replacement

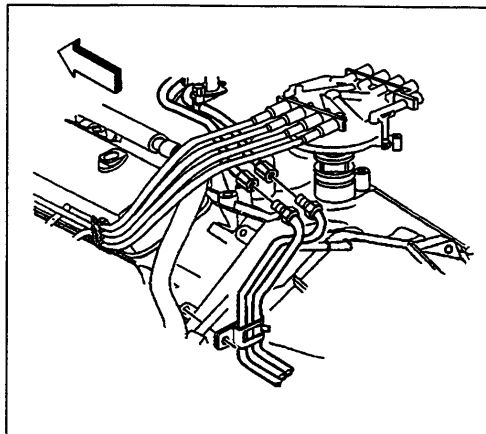
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System (ERROR - NOT IN CURRENT PSD)*.
3. Remove the air cleaner assembly.
4. Remove the upper radiator hose. Refer to *Radiator Hose Replacement (5.0L)* in Engine Cooling.
5. Remove both heater hoses. Refer to *Heater Hoses Replacement (Inlet Hose - 5.0L, 5.7L, 7.4L)* and *Heater Hoses Replacement (Outlet Hose - 5.0L, 5.7L)* in Engine Cooling.

Engine

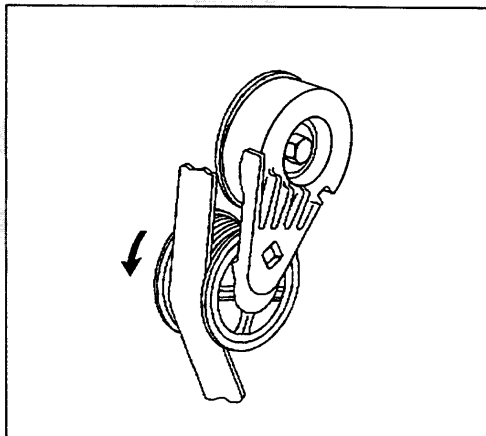
Engine Mechanical - 5.0L, 5.7L 6-81

6. Disconnect the spark plug wires from the distributor cap.
7. Remove the distributor cap.
8. Remove the water pump inlet hose from the water pump.



343625

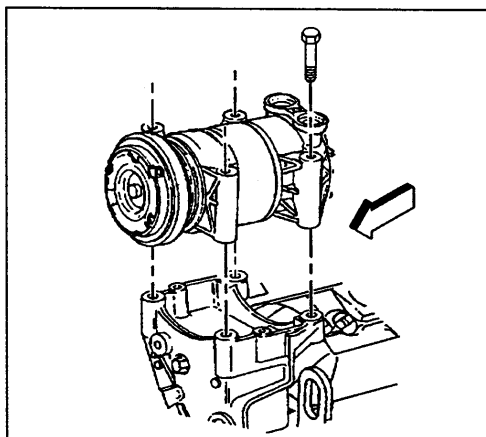
9. Remove the drive belt. Refer to *Drive Belt Replacement*.



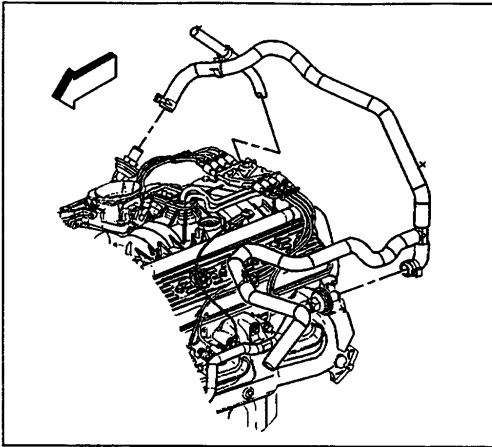
177620

Important: It is not necessary to evacuate the A/C refrigerant.

10. Remove the A/C compressor from the power steering bracket, if equipped, and set it aside.

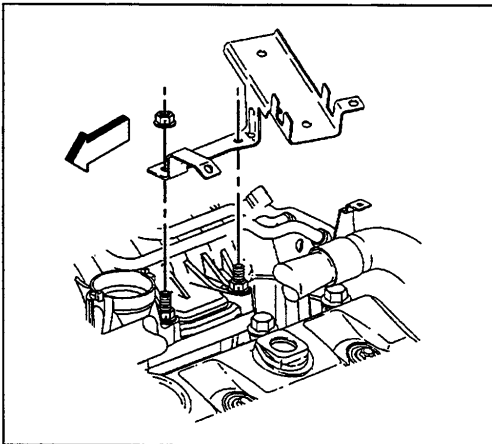


179249



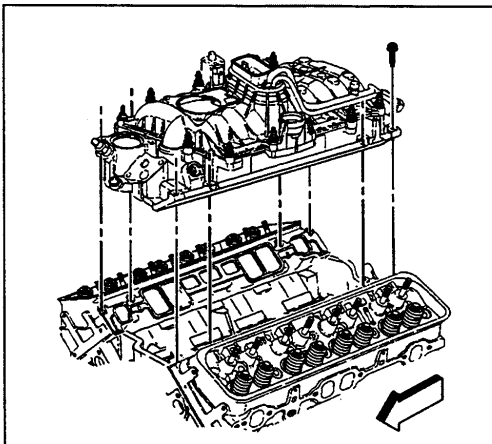
341228

11. Remove AIR check valve (crossover) pipe, if so equipped.



179250

12. Remove the wiring bracket from the rear of the cylinder head.
13. Disconnect the accessory bracket and slide it forward.



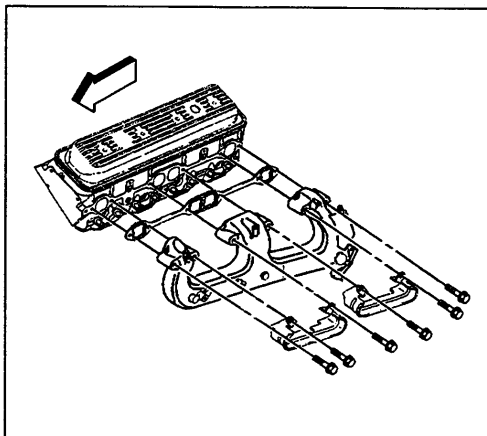
343948

14. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

Engine

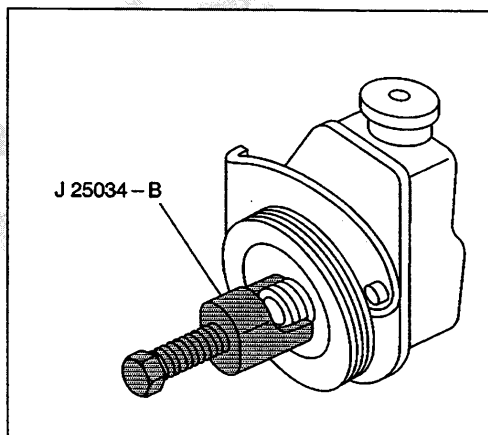
Engine Mechanical - 5.0L, 5.7L 6-83

15. Remove the exhaust manifold. Refer to *Exhaust Manifold Replacement (Left Side)*.
16. Remove the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Removal*.



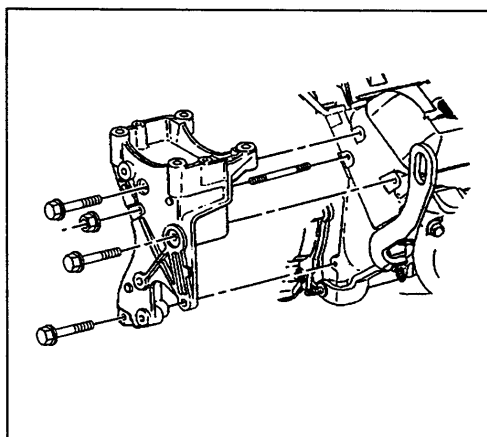
344217

17. Remove the power steering pump pulley.

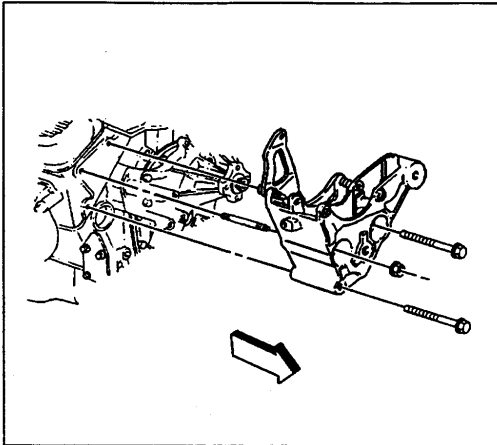


188649

18. Remove the power steering pump mounting bracket using the following procedure:
 - 18.1. Disconnect the electrical connector from the power steering pump.
 - 18.2. Remove the two nuts holding the power steering pump to the engine.
 - 18.3. Remove the power steering pump mounting bracket bolts and the nut.
 - 18.4. Slide the power steering pump mounting bracket forward with the power steering pump still attached.
 - 18.5. Set the power steering pump and the mounting bracket aside.
 - 18.6. Remove the stud.
19. Disconnect the wiring bracket from the rear of the right cylinder head.

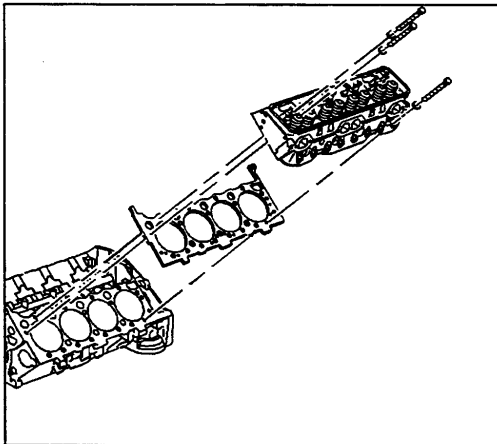


188295



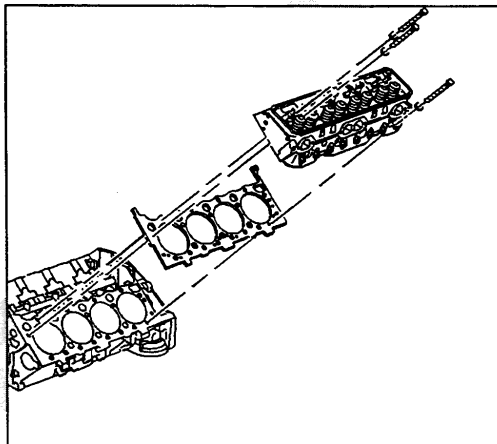
344131

20. For the right side cylinder head, remove the following components:
 - Generator. Refer to *Generator Replacement (ERROR - NOT IN CURRENT PSD)*.
 - Oil indicator tube bracket bolt.
21. Remove the generator and drive belt tensioner bracket using the following procedure:
 - 21.1. Remove the one nut.
 - 21.2. Remove the three bolts.
 - 21.3. Slide the generator and drive belt tensioner bracket off of the stud.
 - 21.4. Remove the stud.



11482

22. Remove the sixteen cylinder head bolts.
23. Remove the cylinder head and the gasket.
24. Clean all sealing surfaces. Refer to *Cylinder Head Clean and Inspect*.



11482

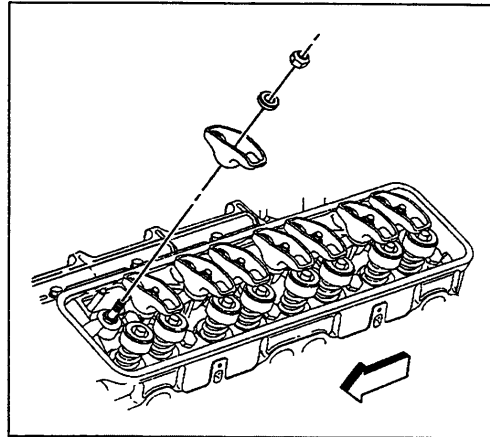
Installation Procedure

Tools Required

J 36660 Torque Angle Meter

1. Install the cylinder head.

2. Install the valve rocker arms and the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Installation*.



343916

3. For the left side cylinder head, install the power steering pump mounting bracket using the following procedure:

Notice: Refer to *Fastener Notice* in Cautions and Notices.

- 3.1. Install the stud to the cylinder head.

Tighten

Tighten the stud to 20 N.m (15 lb ft).

- 3.2. Loosely assemble the mounting bracket over the stud.

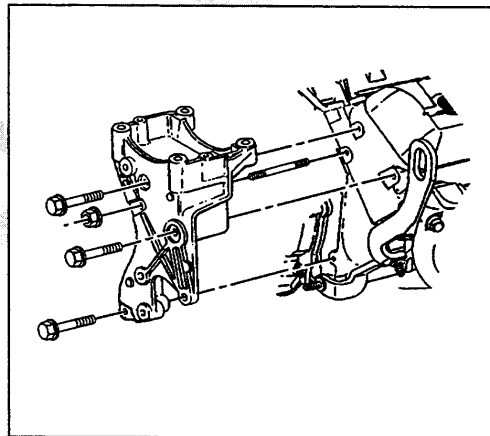
- 3.3. Install a nut to the stud finger tight.

- 3.4. Install the three bolts finger tight.

- 3.5. Install the two nuts to the power steering pump finger tight.

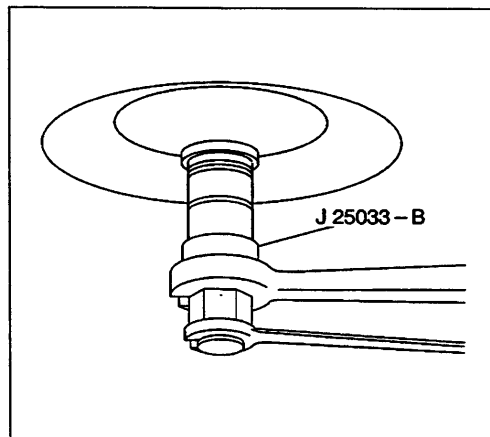
Tighten

Tighten the nuts and bolts to 41 N.m (30 lb ft).

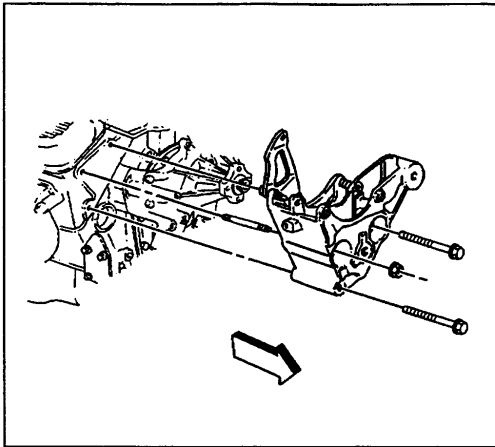


188295

4. Install the power steering pump pulley.
5. Connect the electrical connector to the power steering pump.



188373



344131

6. For the right side cylinder head, install the generator mounting bracket using the following procedure:

- 6.1. Install the stud.

Tighten

Tighten the stud to 20 N.m (15 lb ft).

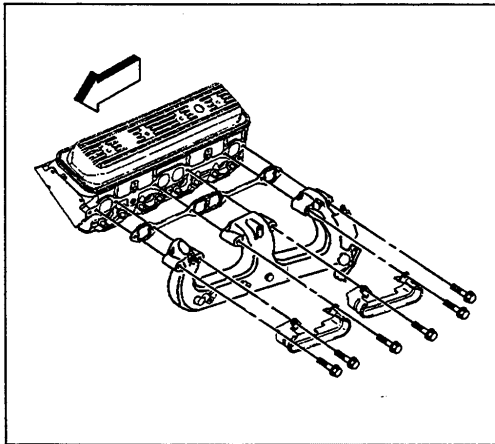
- 6.2. Loosely assemble the generator mounting bracket over the stud.
6.3. Install a nut to the stud finger tight.
6.4. Install the three bolts finger tight.

Tighten

Tighten the nuts and bolts to 41 N.m (30 lb ft).

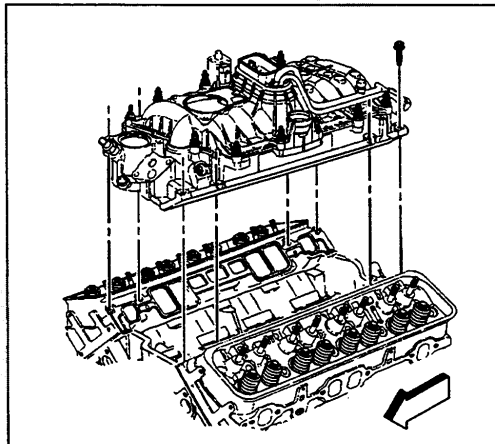
- 6.5. Install the generator. Refer to *Generator Replacement (ERROR - NOT IN CURRENT PSD)*.
6.6. Oil indicator tube bracket bolt. Refer to *Oil Level Indicator and Tube Replacement*.

7. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement (Left Side)*.



344217

8. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

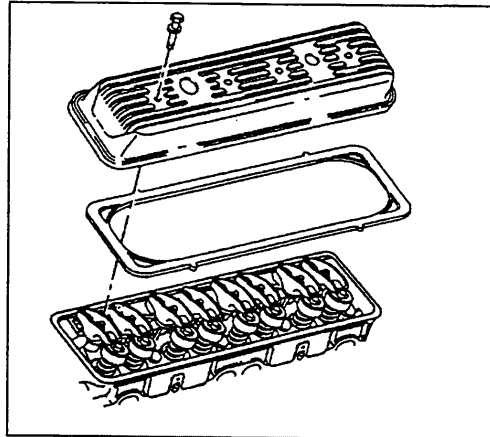


343948

Engine

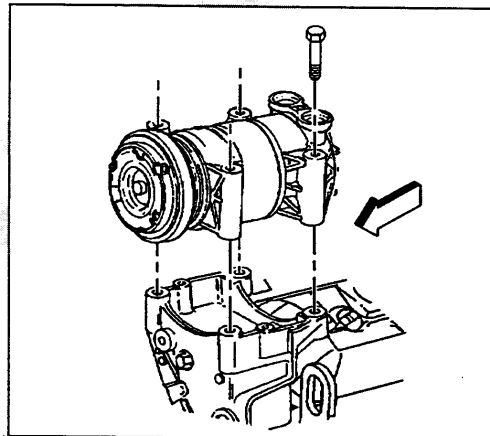
Engine Mechanical - 5.0L, 5.7L 6-87

9. Install the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement*.
10. Install the wiring bracket to the rear of the cylinder head.
11. Connect the accessory bracket.



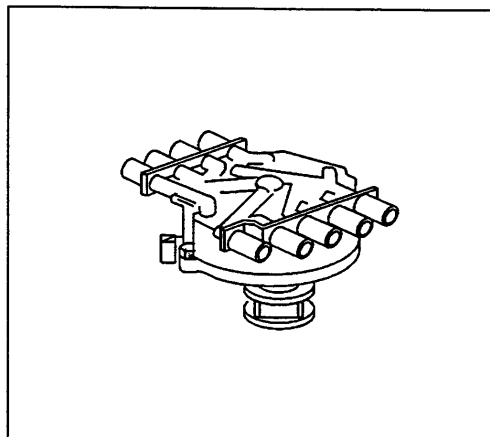
68709

12. Install the A/C compressor, if equipped. Refer to *Compressor Replacement in HVAC*.
13. Install the drive belt. Refer to *Drive Belt Replacement*.



179249

14. Install the distributor cap.
15. Connect the spark plug wires to the distributor cap.
16. Install both heater hoses. Refer to *Heater Hoses Replacement (Outlet Hose - 5.0L, 5.7L)* in HVAC.
17. Install the upper radiator hose. Refer to *Heater Hoses Replacement (Inlet Hose - 5.0L, 5.7L, 7.4L)* in Engine Cooling.
18. Install the air cleaner assembly.
19. Refill the cooling system. Refer to *Draining and Filling Cooling System (ERROR - NOT IN CURRENT PSD)*.
20. Connect the battery negative cable.

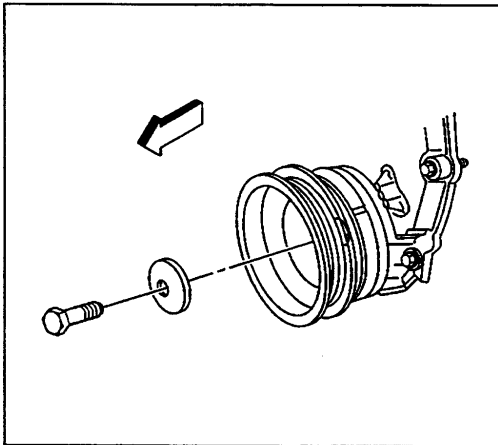


344232

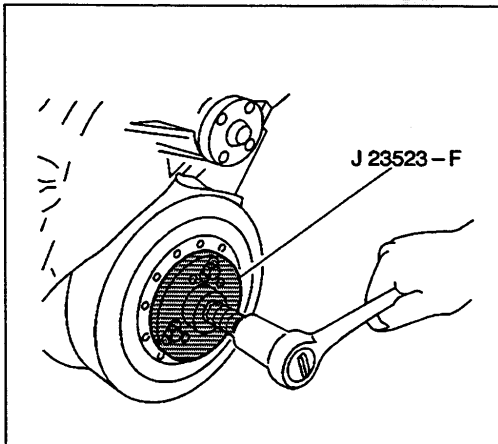
SIE-ID - 332436

Crankshaft Balancer Replacement**Removal Procedure****Tools Required***J 23523-F* Crankshaft Balancer Remover

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.
2. Remove the fan shroud assembly. Refer to *Fan Shroud Replacement (Upper)* and *Fan Shroud Replacement (Lower)* in Engine Cooling.
3. Remove the drive belt. Refer to *Drive Belt Replacement*.
4. Remove the crankshaft balancer.
5. Clean and inspect all parts. Refer to *Crankshaft Balancer Clean and Inspect*.



173172

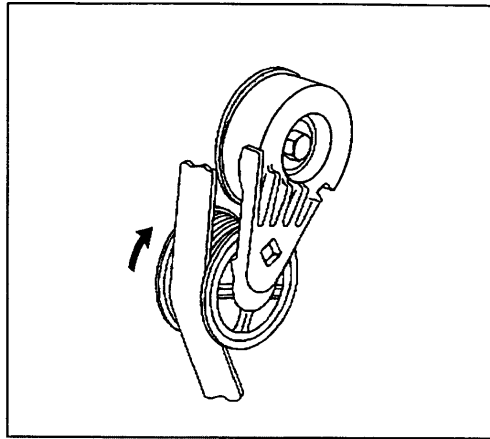


4059

Installation Procedure**Tools Required***J 39046* Crankshaft Balancer Installer

1. Install the crankshaft balancer. Refer to *Crankshaft Balancer Installation*.

2. Install the drive belt. Refer to *Drive Belt Replacement*.
3. Install the fan shroud assembly. Refer to *Fan Shroud Replacement (Upper)* and *Fan Shroud Replacement (Lower)* in Engine Cooling.
4. Connect the battery negative cable.



177622

SIE-ID = 332446

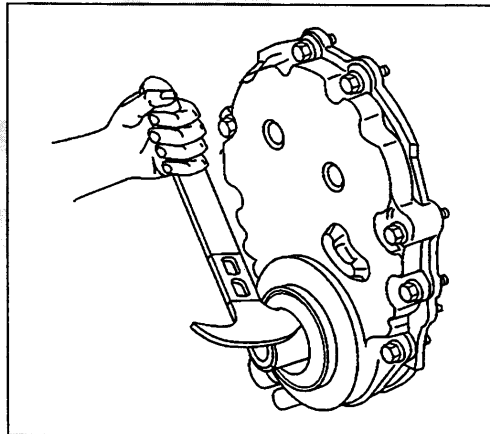
Crankshaft Front Cover Oil Seal Replacement

Removal Procedure

Tools Required

4.3L On Vehicle Front Crankshaft Oil Seal Removal

1. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
2. Use a suitable prying tool to remove the crankshaft front oil seal.
3. Inspect the engine front cover seal bore for damage.
4. Inspect the crankshaft balancer sealing surface for damage. Refer to *Crankshaft Balancer Clean and Inspect*.



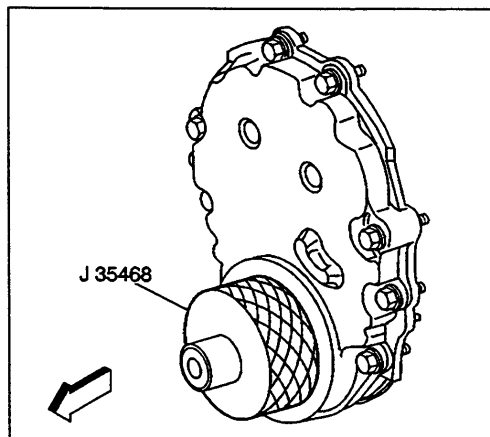
357563

Installation Procedure

Tools Required

J 35468 Cover Aligner/Seal Installer

1. Look to ensure that the pre-applied grease on the crankshaft front oil seal is intact.
2. Use the J 35468 Cover Aligner/Seal Installer in order to install the crankshaft front oil seal.
3. Inspect to ensure the crankshaft front oil seal is flush and square to the engine front cover.
4. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.

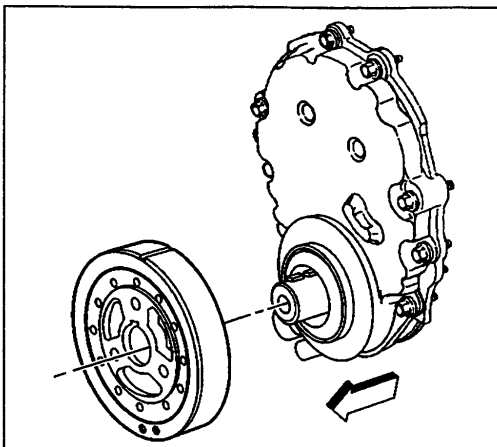


357566

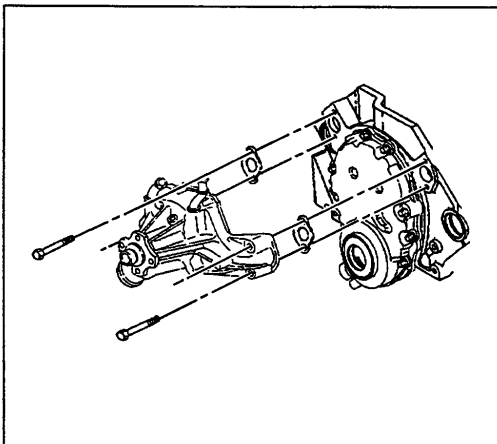
SIE-ID = 332450

Engine Front Cover Replacement**Removal Procedure**

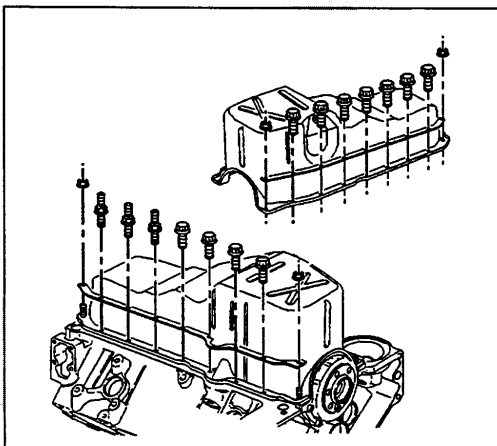
1. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
2. Remove the water pump. Refer to *Water Pump Replacement (Diesel)*.
3. Drain the engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
4. Remove all the engine oil pan fasteners except the two nuts at the rear of the engine.
5. Carefully separate the engine oil pan from the engine front cover.
6. Disconnect the crankshaft position (CKP) sensor wire.



182832



69011

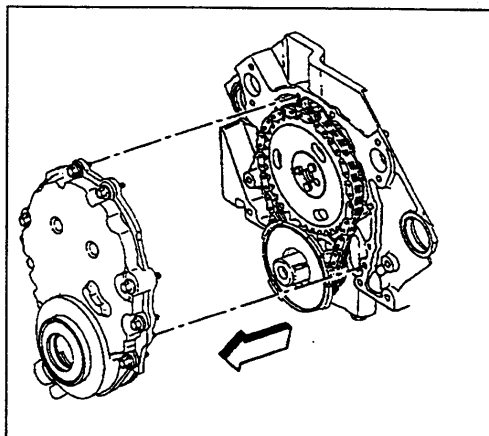


176054

Engine

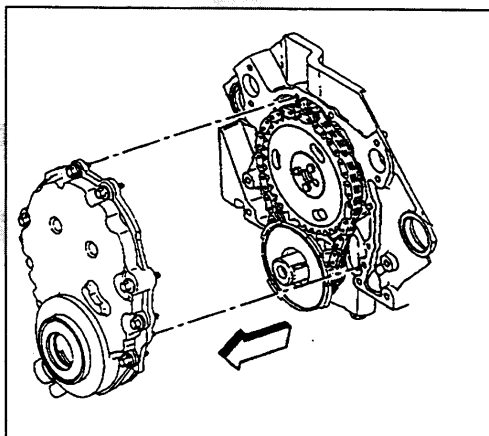
Engine Mechanical - 5.0L, 5.7L 6-91

7. Remove the engine front cover and gasket. Refer to *Crankshaft Front Cover Oil Seal Replacement*.



Installation Procedure

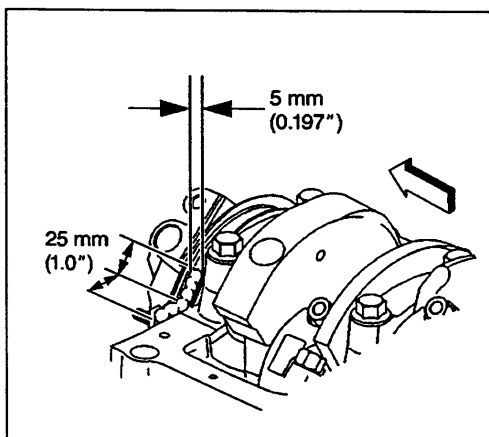
1. Install the engine front cover. Refer to *Crankshaft Front Cover Oil Seal Replacement*.

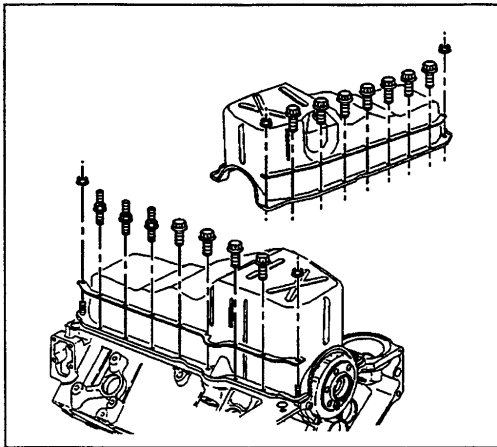


2. Clean all the adhesive from the corners of the oil pan gasket where it meets the engine front cover.

Important: The oil gasket and the oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive, GM P/N 12346141 or equivalent, to the engine front cover to engine block junction at the oil pan sealing surfaces.





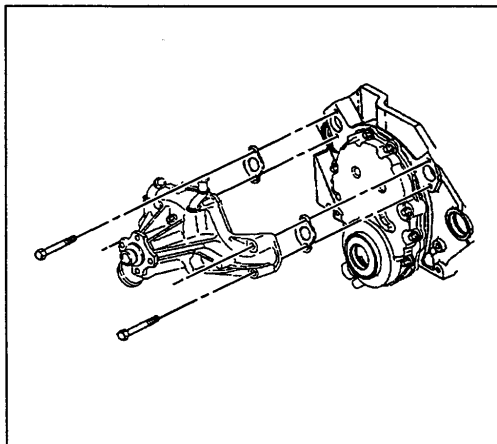
176054

Caution: Refer to *Battery Disconnect Caution in Cautions and Notices*.

4. Install the engine oil pannuts and bolts.

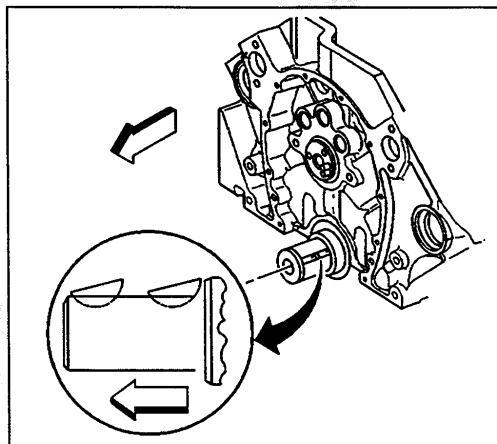
Tighten

- 4.1. Tighten the oil pan bolts to 12 N.m(106 lb in).
- 4.2. Tighten the oil pan nuts to 25 N.m(10 lb ft).
5. Connect the crankshaft position (CKP) sensor wire.



69011

6. Install the water pump. Refer to *Water Pump Replacement (Diesel)*.



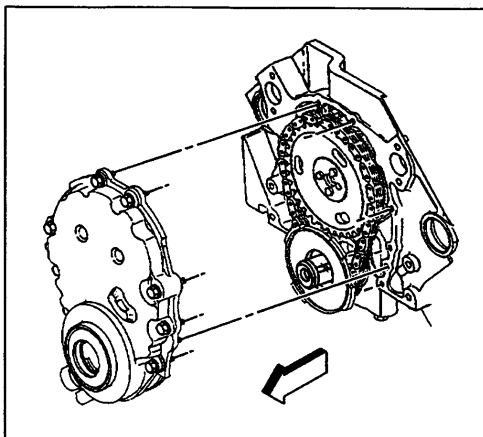
182847

7. Install the crankshaft balancer. Refer to *Crankshaft Balancer Installation*.

SIE-ID - 332452

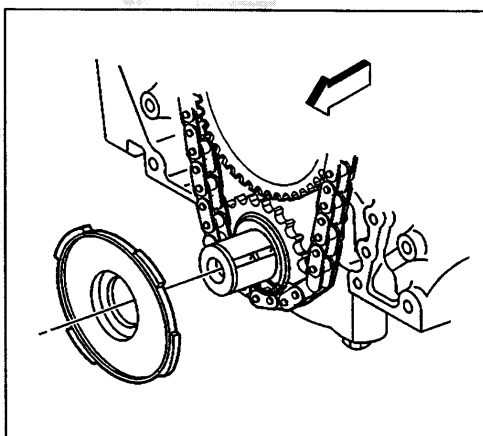
Crankshaft Position Reluctor Ring Replacement**Removal Procedure**

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.



344274

2. Remove the crankshaft position sensor reluctor ring.



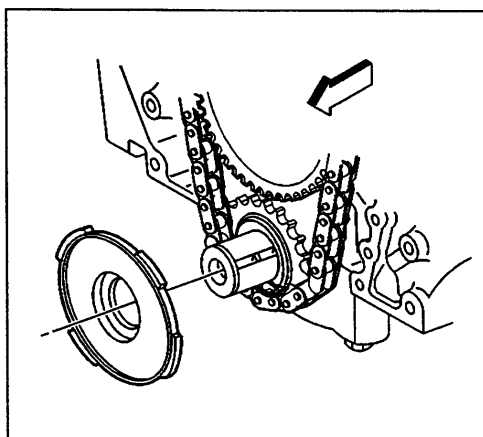
69450

Installation Procedure

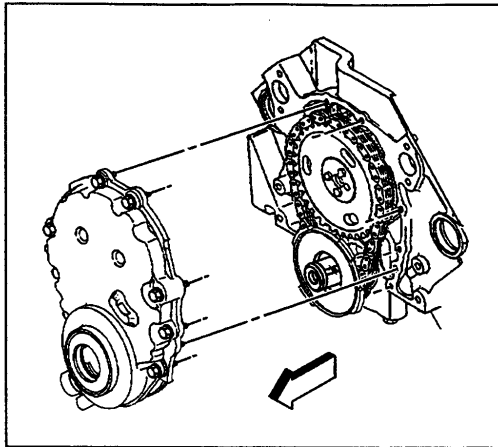
Notice: SIO-ID - 23526 Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

Important: The reluctor ring is shaped like a dish. The dish must face the engine front cover. Failure to do so will damage the engine front cover and the reluctor ring.

1. Install the crankshaft position sensor reluctor ring.
 - 1.1. Align the keyway on the crankshaft position sensor reluctor ring with the woodruff key (crankshaft balancer) in the crankshaft.
 - 1.2. Push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.

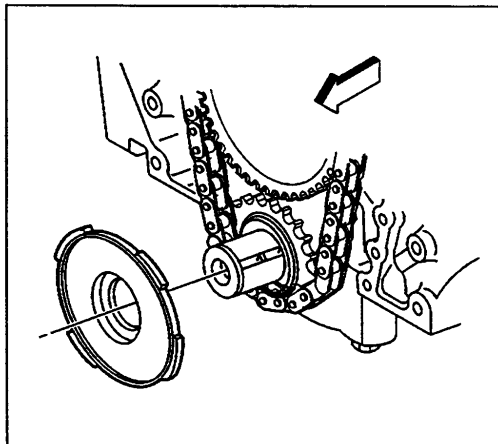


69450



344274

2. Install the engine front cover. Refer to *Engine Front Cover Replacement*.



69450

SIE-ID - 332456

Timing Chain and Sprockets Replacement

Removal Procedure

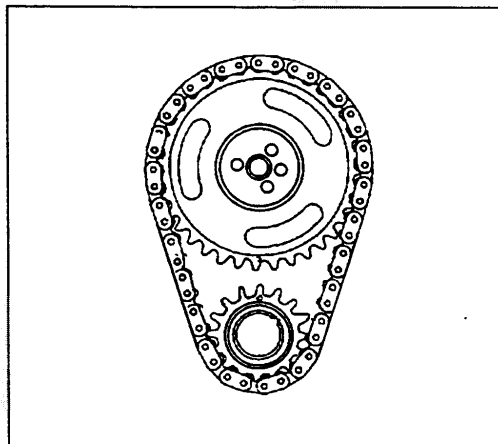
Tools Required

J 5825-A Crankshaft Gear Remover

1. Remove the engine front cover and the crankshaft position sensor reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.

Important: Once the engine front cover is removed, do not re-install it.

Always install a NEW engine front cover.



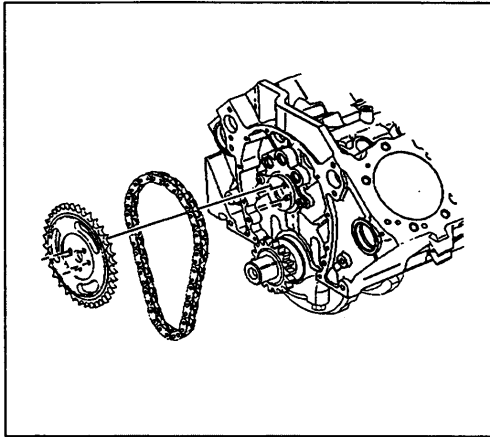
344371

2. Rotate the crankshaft until:
 - 2.1. The number one cylinder is at top dead center (TDC) of the compression stroke.
 - 2.2. The timing marks on both sprockets line up.

Engine

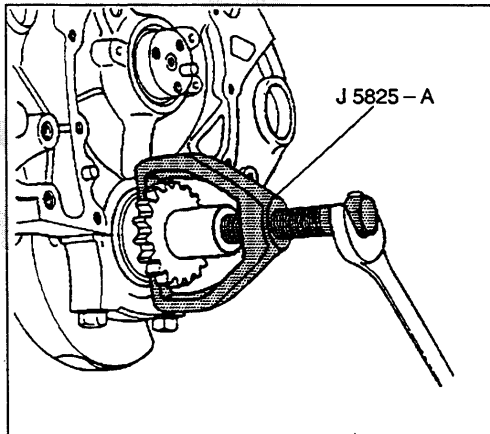
Engine Mechanical - 5.0L, 5.7L 6-95

3. Remove the camshaft sprocket bolts.
4. Remove the camshaft sprocket and the camshaft timing chain.



344368

5. Use the *J 5825-A* in order to remove the crankshaft sprocket.
6. Remove the woodruff key (crankshaft balancer), if necessary.
7. Inspect all parts for wear or damage. Refer to *Timing Chain and Sprockets Clean and Inspect*.



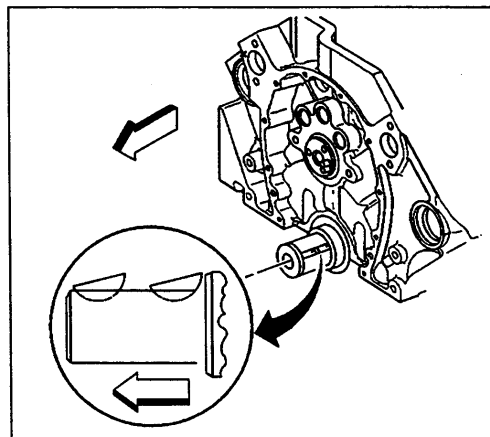
11506

Installation Procedure

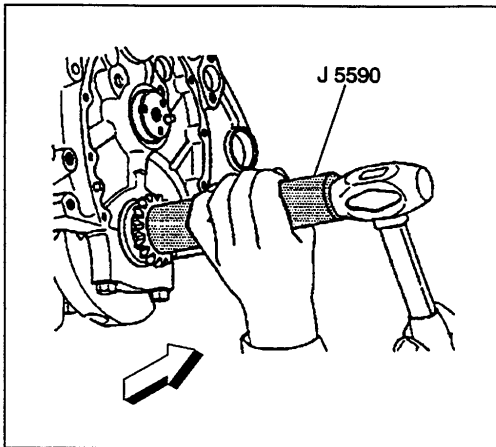
Tools Required

J 5590 Crankshaft Sprocket Installer

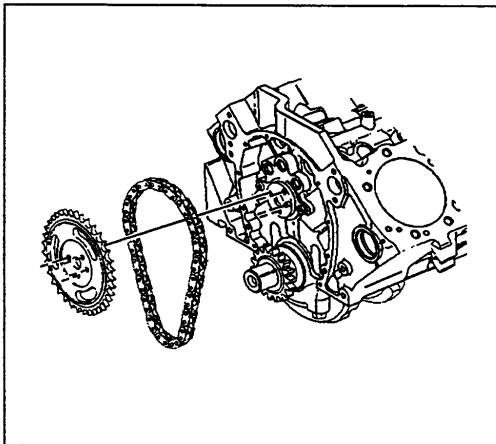
1. Install the woodruff key (crankshaft balancer) into the crankshaft, if removed.



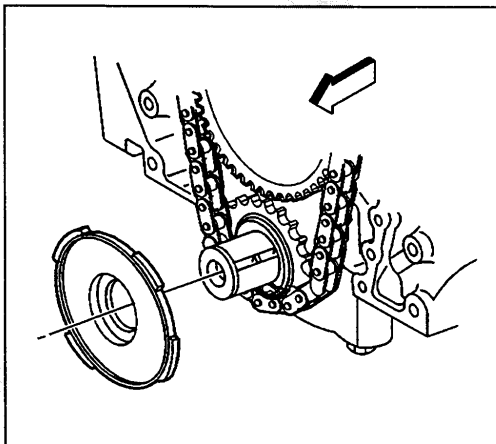
182847



32066



344368



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Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

2. Align the keyway of the crankshaft sprocket with the woodruff key (crankshaft balancer).
3. Use the *J 5590* and a hammer in order to install the crankshaft sprocket.
4. Make sure that the number 1 piston is still at TDC of the compression stroke.
5. Align the timing marks on both sprockets. Look to ensure that the crankshaft sprocket alignment mark is in the 12 o'clock position.

6. Install the camshaft sprocket and the camshaft timing chain. The camshaft sprocket alignment mark must be in the 6 o'clock position.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the camshaft sprocket bolts.

Tighten

Tighten the bolts to 25 N.m (18 lb ft).

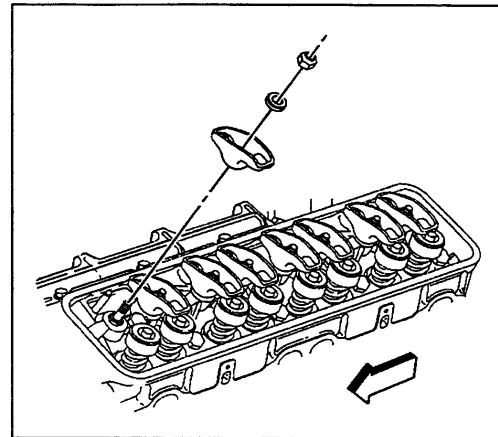
8. Look to ensure that the camshaft sprocket and the crankshaft sprocket alignment marks.

9. Install the crankshaft position sensor reluctor ring and the engine front cover. Refer to *Crankshaft Position Reluctor Ring Replacement*.

SIE-ID - 332464

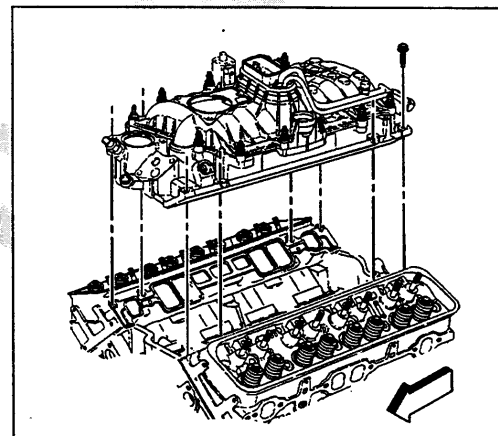
Camshaft Replacement**Removal Procedure**

1. Evacuate the air conditioning system, if equipped. Refer to *Refrigerant Recovery and Recharging* Recharging the Refrigerant System in HVAC.
2. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.
3. Drain the engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
4. Remove the valve rocker arms and valve pushrods. Refer to *Engine Oil and Oil Filter Replacement*.



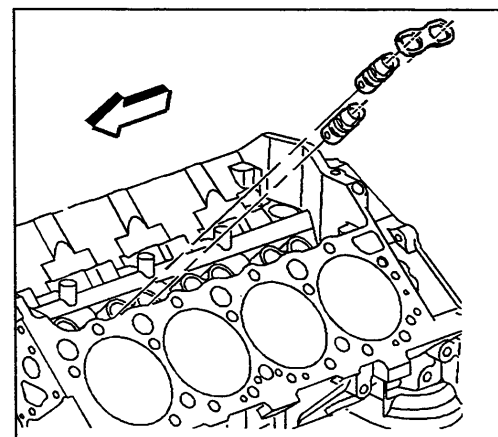
343916

5. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

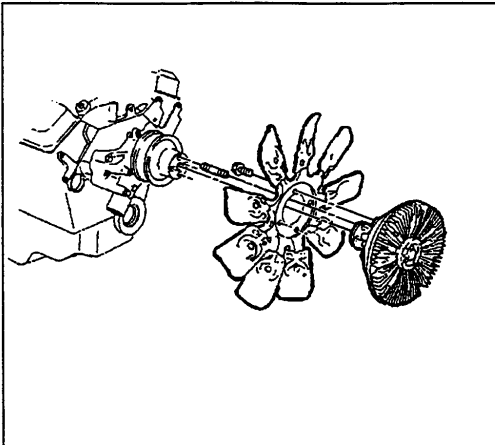


343948

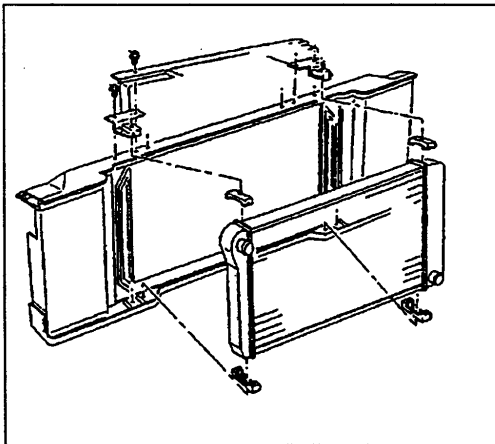
6. Remove the valve lifters. Refer to *Valve Lifter Replacement*.



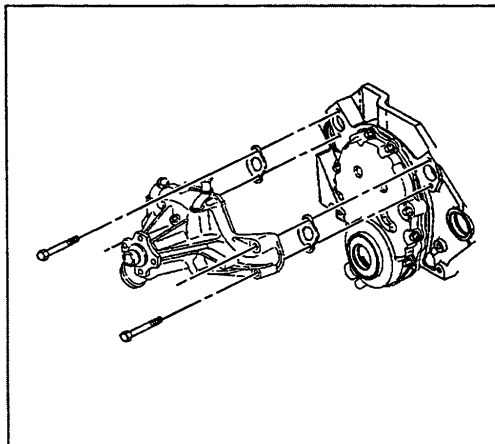
11509



108015



72749



69011

7. Remove the engine cooling fan and the fan shroud. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)*.
8. Remove the radiator grille. Refer to *Grille Replacement (Luxury)*.
9. Remove the hood latch bracket. Refer to *Hood Latch Replacement (Primary)*.

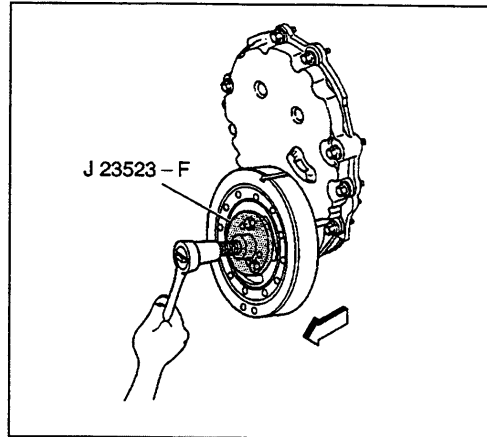
10. Remove the radiator. Refer to *Radiator Replacement*.
11. Remove the A/C condenser, if equipped. Refer to *Condenser Replacement*.

12. Remove the water pump. Refer to *Water Pump Replacement (Diesel)*.

Engine

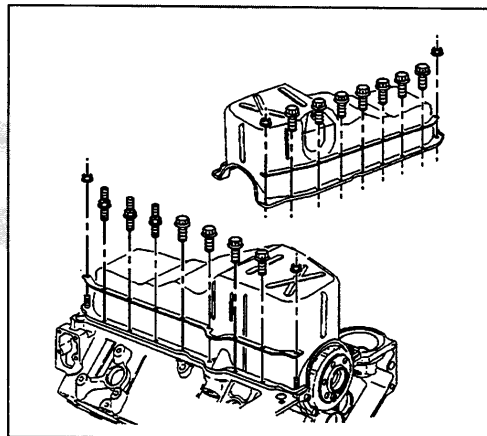
Engine Mechanical - 5.0L, 5.7L - 6-99

13. Remove the three crankshaft pulley bolts and the crankshaft pulley.
14. Use the *J 23523-F* in order to remove the crankshaft balancer.
Refer to *Crankshaft Balancer Replacement*.



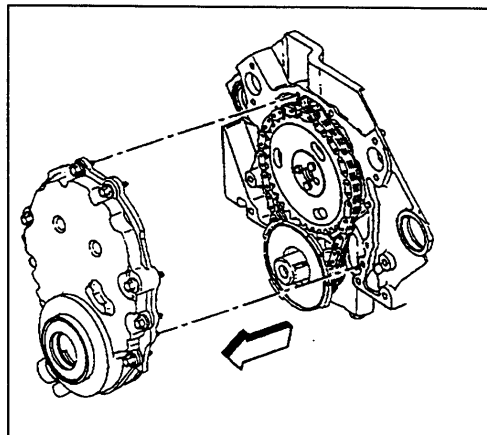
66878

15. Raise the vehicle.
16. Remove the following fasteners from the oil pan:
 - Two nuts at the front of the engine.
 - Eleven screws and three studs.**Important:** Do not remove the two nuts at the rear of the engine.
17. Lower the vehicle.

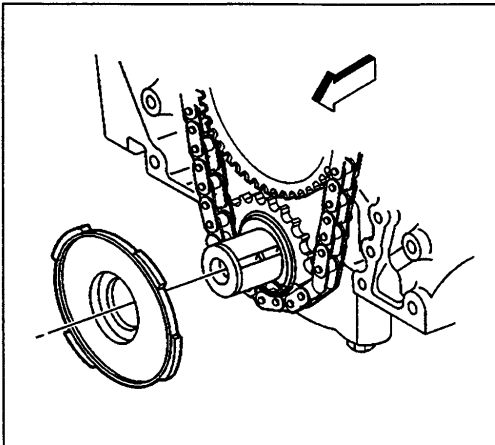


176054

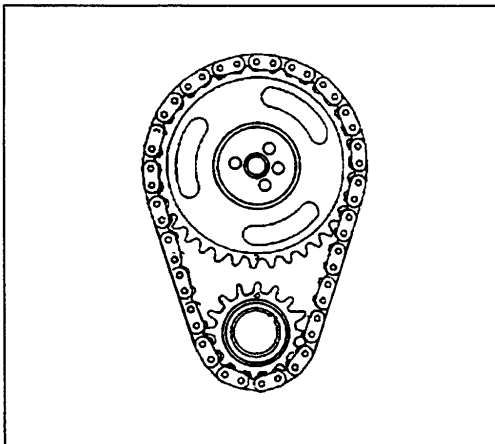
18. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.



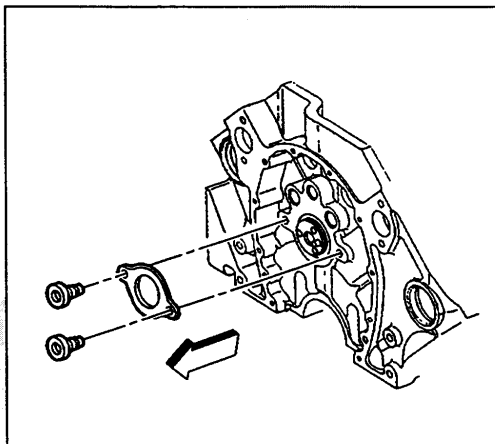
69010



69450



344371



182836

19. Remove the crankshaft position sensor reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.

20. Rotate the number one piston to Top Dead Center (TDC).

21. Align the timing marks on the camshaft and the crankshaft sprockets.

22. Remove the camshaft sprocket bolts.

23. Remove the camshaft sprocket and the timing chain. Refer to *Timing Chain and Sprockets Replacement*.

24. Remove the camshaft retainer plate and bolts using a T-30 TORX® socket.

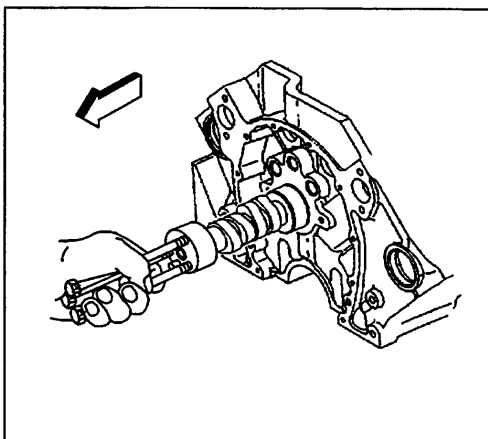
Engine

Engine Mechanical - 5.0L, 5.7L 6-101

Notice: S10-ID - 13833 All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

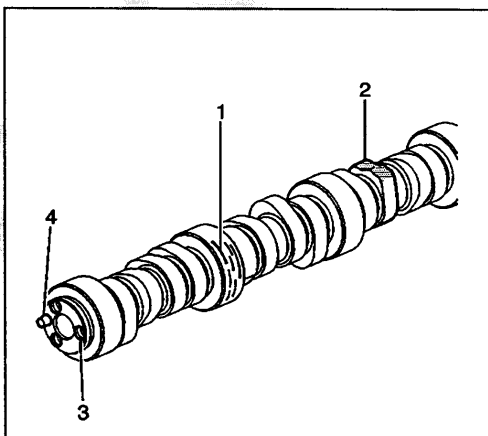
Important: All camshaft journals are the same diameter, so care must be used in removing the camshaft to avoid damage to the bearings.

25. Remove the engine camshaft.
 - 25.1. Install the three 5/16-18 x 4.0 in bolts in the engine camshaft front bolt holes.
 - 25.2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
 - 25.3. Remove the bolts from the front of the engine camshaft.



344428

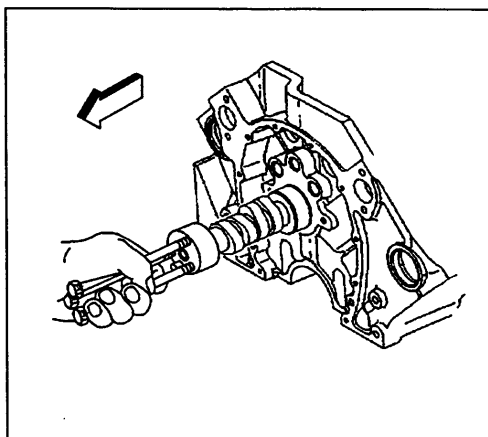
26. Clean all sealing surfaces.
27. Inspect all parts for wear. Refer to *Camshaft and Bearings Clean and Inspect*.



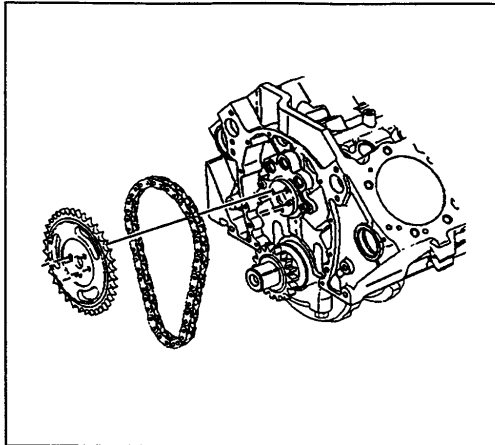
188095

Installation Procedure

1. Install the camshaft. Refer to *Camshaft Installation*.

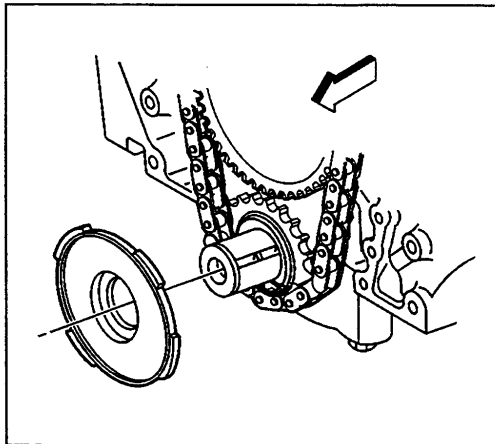


344428



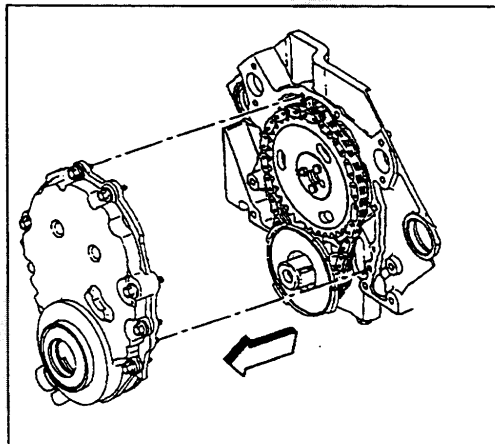
344368

2. Install the components removed from the front of the engine. Refer to *Timing Chain and Sprockets Replacement*.



69450

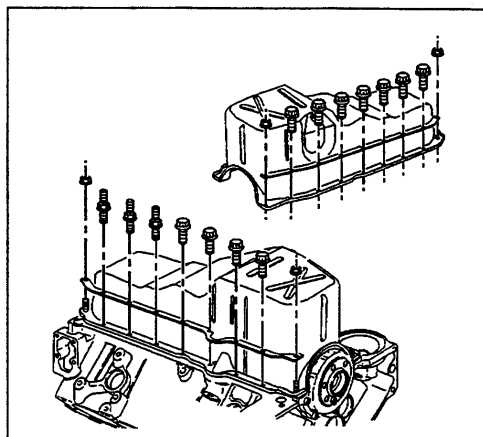
3. Install the crankshaft reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.



69010

4. Install the engine front cover. Refer to *Engine Front Cover Replacement*.

5. Raise the vehicle.
6. Install the fasteners to the oil pan. Refer to *Oil Pan Installation*.
7. Lower the vehicle.



176054

8. Use *J 23523-F* in order to install the crankshaft balancer. Refer to *Crankshaft Balancer Installation*.

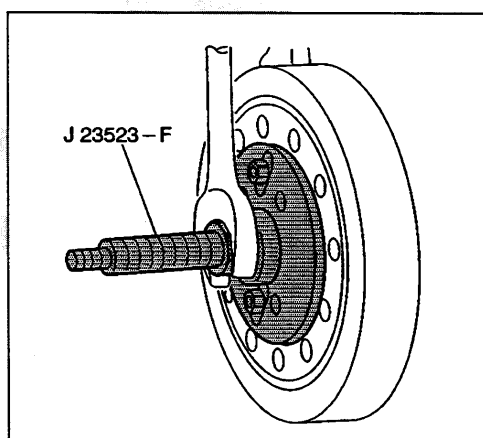
Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Install the crankshaft pulley in the following manner:

- 9.1. Install the pulley and the three bolts.
- 9.2. Install the crankshaft balancer bolt.

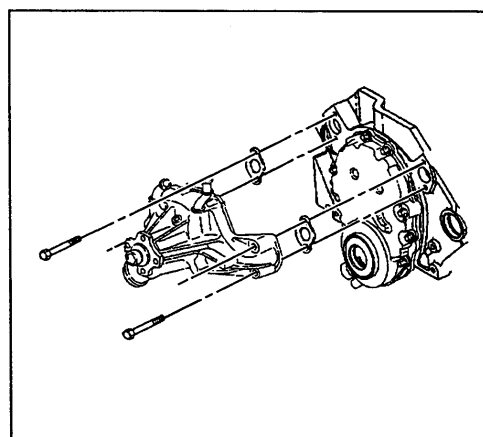
Tighten

- 9.2.1 Tighten the pulley bolts to 58 N·m (43 lb ft).
- 9.2.2 Tighten the crankshaft balancer bolt to 95 N·m (70 lb ft).

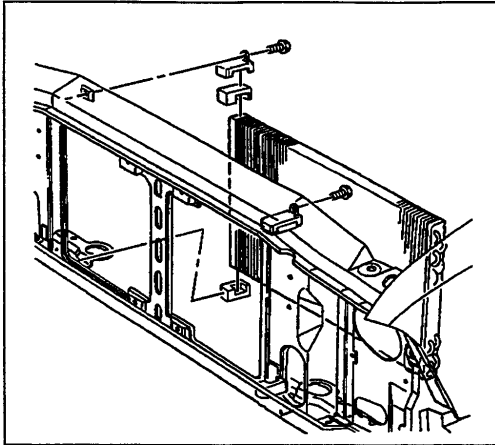


4065

10. Install the water pump. Refer to *Water Pump Replacement (Diesel)*.

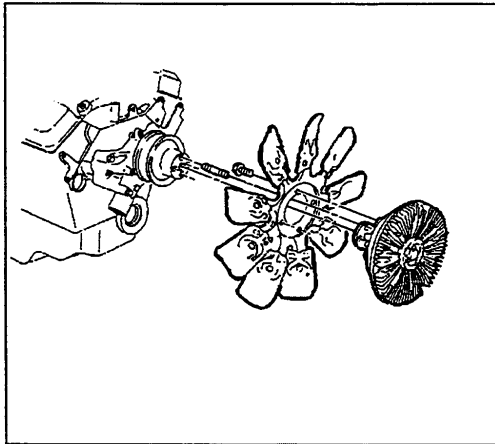


69011



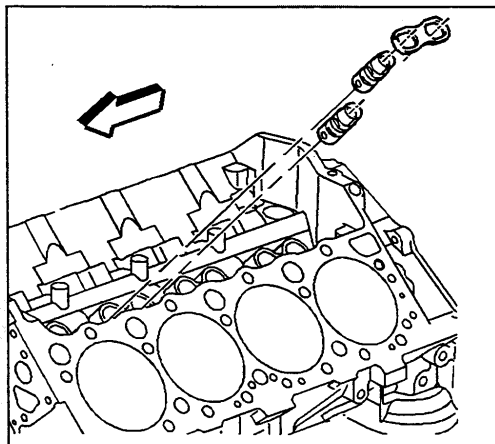
199015

11. Install the A/C condenser, if equipped. Refer to *Condenser Replacement*.
12. Install the radiator. Refer to *Radiator Replacement*.
13. Install the hood latch bracket. Refer to *Hood Latch Replacement (Primary)*.
14. Install the radiator grille. Refer to *Grille Replacement (Luxury)*.



108015

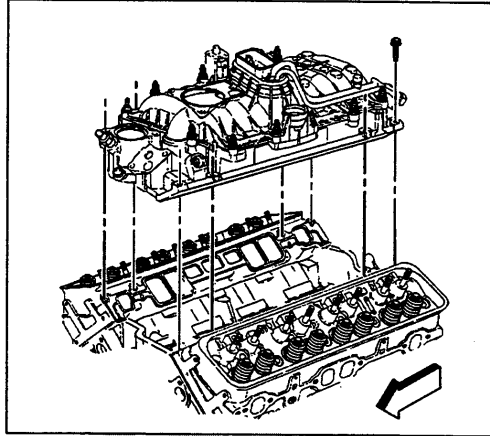
15. Install the engine cooling fan and the upper fan shroud. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)*.



11509

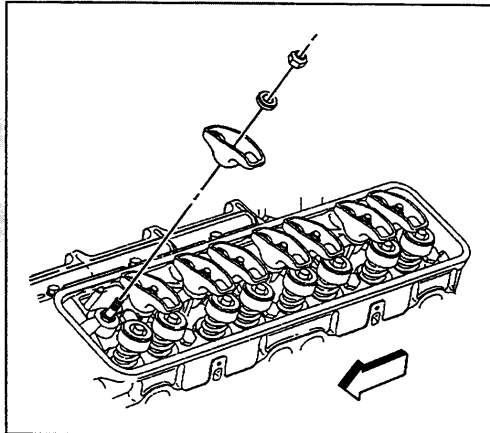
16. Install the components removal from the top of the engine. Refer to *Valve Lifter Replacement*.

17. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



343948

18. Install the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Installation*.
19. Connect the battery negative cable.
20. Recharge the air conditioning system, if equipped. Refer to *Recharging the Refrigerant System in HVAC*.
21. Fill the engine with the proper type and quantity of engine oil.
22. Replace the engine oil filter. Refer to *Engine Oil and Oil Filter Replacement*.



343916

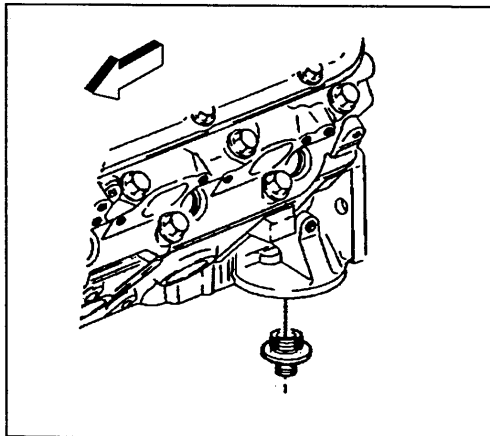
SIE-ID = 332471

Oil Filter Adapter and Valve Assembly Replacement

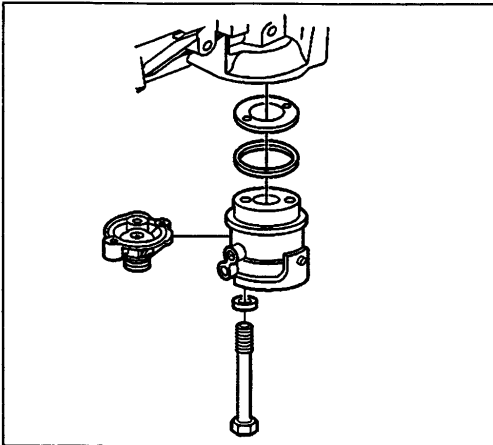
Removal Procedure

Oil Filter Bypass Valve

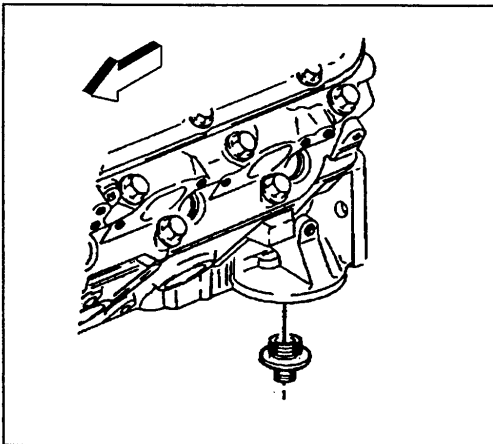
1. Remove the oil filter. Refer to *Engine Oil and Oil Filter Replacement*.
2. Remove the bolts.
3. Remove the oil filter bypass valve.
4. Inspect the bypass valve spring and valve disc for proper operation, cracks, and damage. Replace the oil filter bypass valve if necessary.
5. Clean the valve chamber in the engine block.



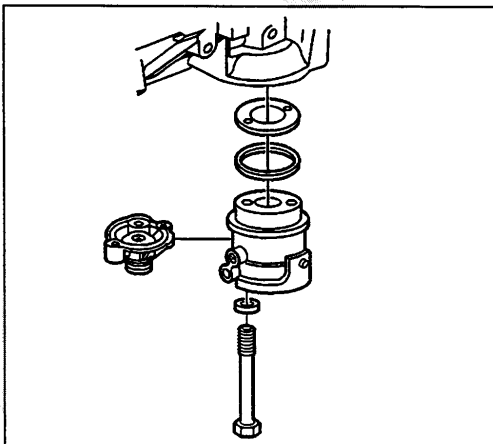
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Oil Filter Adapter

1. Remove and discard the oil filter.
Refer to *Engine Oil and Oil Filter Replacement*.
2. Remove the oil cooler pipes.
3. Remove the oil filter adapter.
4. Clean all sealing surfaces.

Installation Procedure**Oil Filter Bypass Valve**

1. Install the oil filter bypass valve and a new gasket.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the bolts finger tight.

Tighten

Tighten the bolts to 25 N·m (18 lb ft).

3. Install the engine oil and the oil filter. Refer to *Engine Oil and Oil Filter Replacement*.

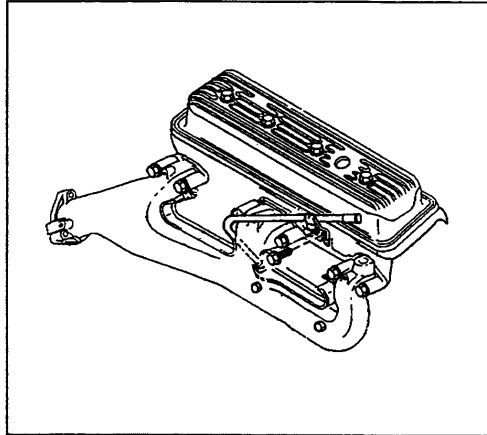
Oil Filter Adapter

1. Install the oil filter adapter.
2. Install the oil cooler pipes.
3. Install the engine oil and the NEW oil filter.
Refer to *Engine Oil and Oil Filter Replacement*.

SIE-ID - 332474

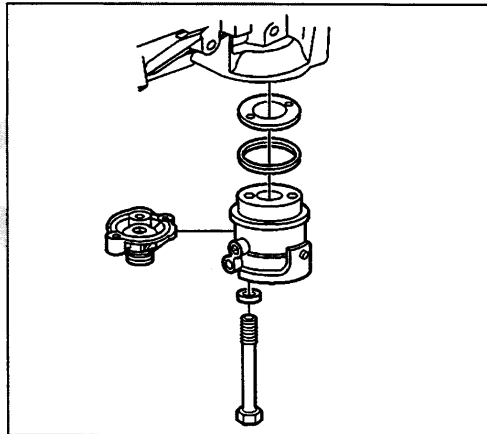
Oil Pan Replacement**Removal Procedure**

1. Remove the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.



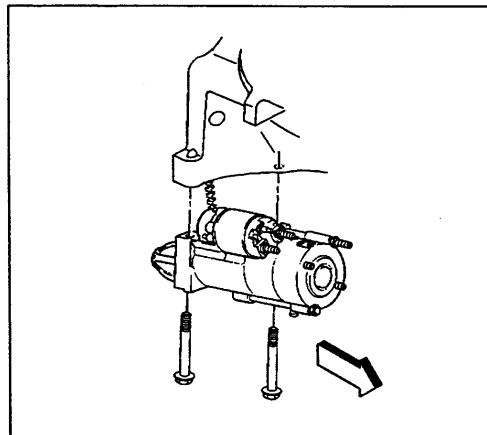
173203

2. Raise the vehicle.
3. Remove the engine oil and the engine oil filter. Refer to *Engine Oil and Oil Filter Replacement*.
4. Remove the oil filter adapter. Refer to *Oil Filter Adapter and Valve Assembly Replacement*.

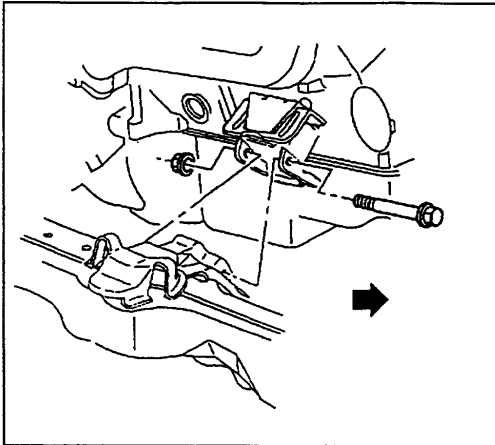


39122

5. Remove the starter. Refer to *Starter Motor Replacement (ERROR - NOT IN CURRENT PSD)*.
6. Remove the flywheel inspection cover.

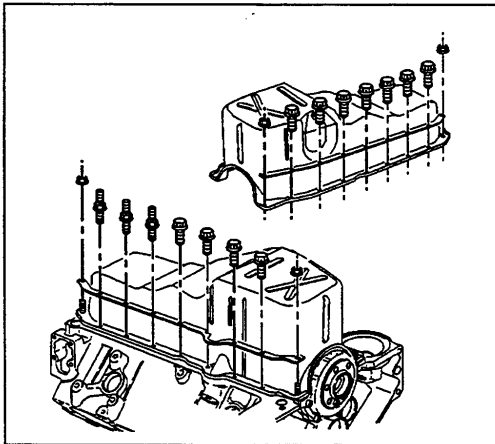


183406



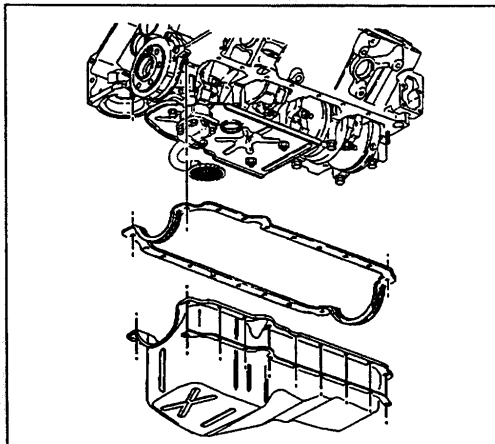
4564

7. Remove the engine mount through bolts. Refer to *Engine Mount Replacement (Front C Model)*.
8. Raise and support the engine.



176054

9. Remove the oil pan nuts and bolts.
Note the location of any studs to assist reassembly.

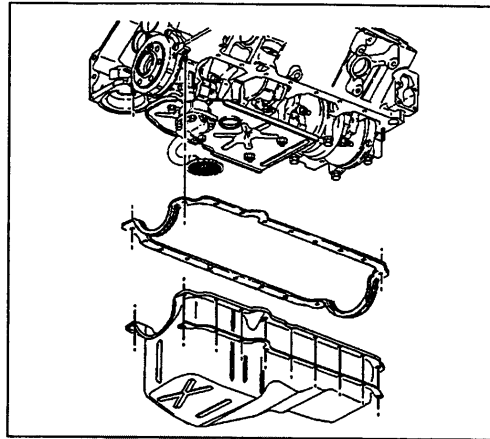


176052

10. Remove the engine oil pan and the gasket.
11. Clean all the sealing surfaces. Refer to *Oil Pan Clean and Inspect*.

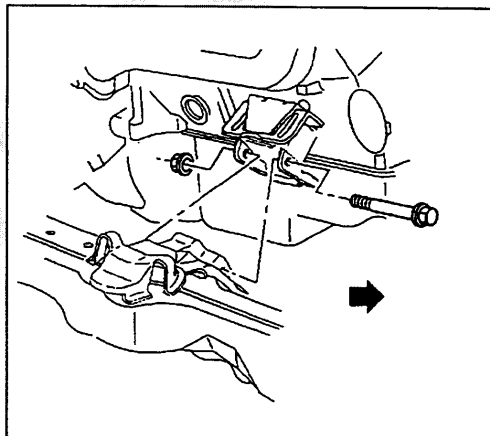
Installation Procedure

1. Install the engine oil pan and a NEW oil pan gasket. Refer to *Oil Pan Installation*.



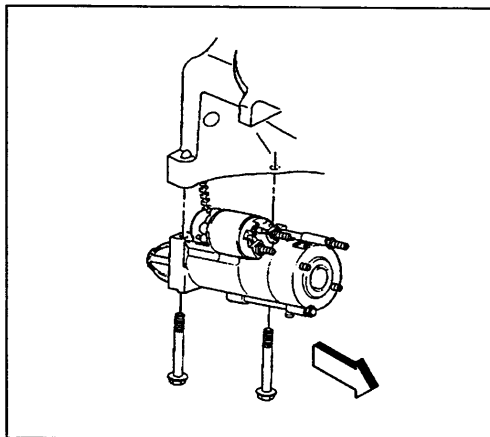
176052

2. Lower the engine onto the engine mounts.
3. Install the engine mount through-bolts. Refer to *Engine Mount Replacement (Front C Model)*.

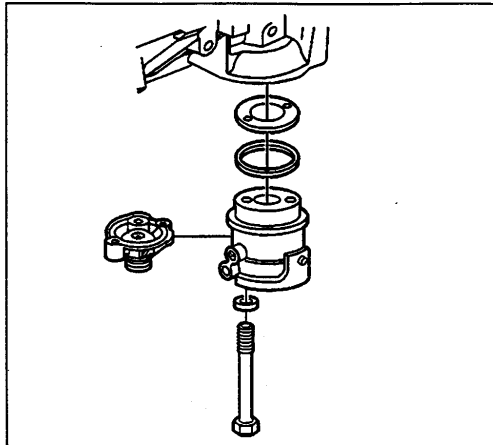


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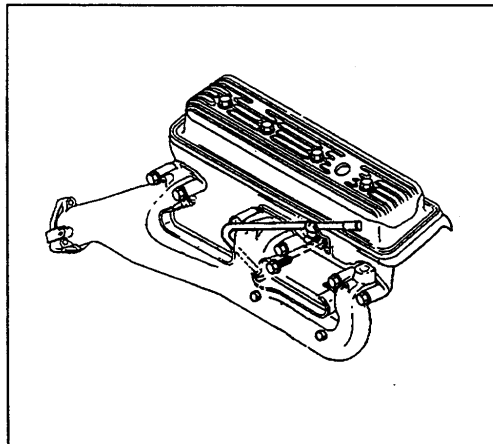
4. Install the starter. Refer to *Starter Motor Replacement (ERROR - NOT IN CURRENT PSD)*.
5. Install the flywheel inspection cover.



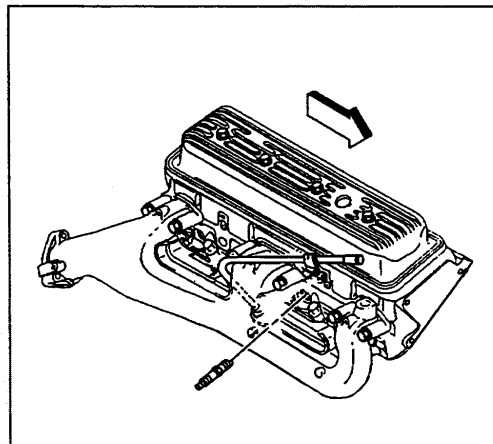
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6. Install the oil filter adapter. Refer to *Oil Filter Adapter and Valve Assembly Replacement*.
7. Install the engine oil filter and the engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
8. Lower the vehicle.

9. Install the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.

SIE-ID = 332475

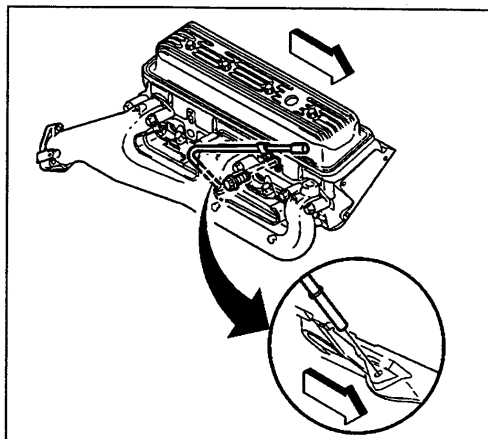
Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the air cleaner assembly.

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.
2. Remove the spark plug wire from the cylinder number 4 spark plug
 - 2.1. Rotate the spark plug wire boot 1/2 turn.
 - 2.2. Pull outward on the spark plug wire boot to release from the spark plug.
3. Remove the spark plug for the number 4 cylinder.
4. Remove the oil level indicator from the oil level indicator tube.

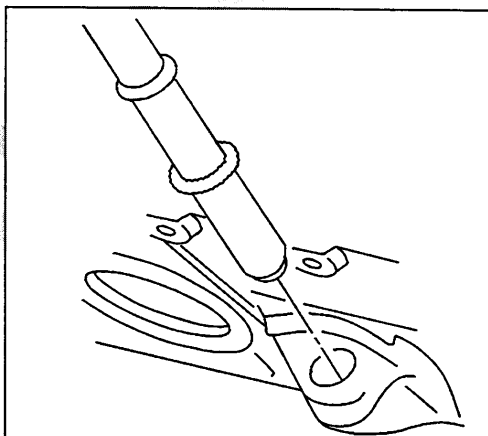
5. Remove the oil level indicator tube bolt.
6. Remove the oil level indicator tube from the engine block using a twisting motion.
7. Clean the old sealer from the oil level indicator tube and the engine block.



182831

Installation Procedure

1. Apply sealant, GM P/N 12346004 or equivalent, around the oil level indicator tube 13 mm(0.5 in) below the tube bead.
2. Install the oil level indicator tube to the engine block. The indicator tube collar must be installed flush to the engine block.
3. Line up the oil level indicator tube with the spark plug retainer.



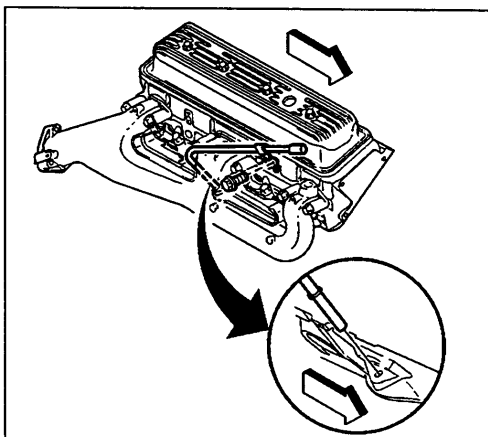
176058

Notice: Refer to *Fastener Notice* in Cautions and Notices.

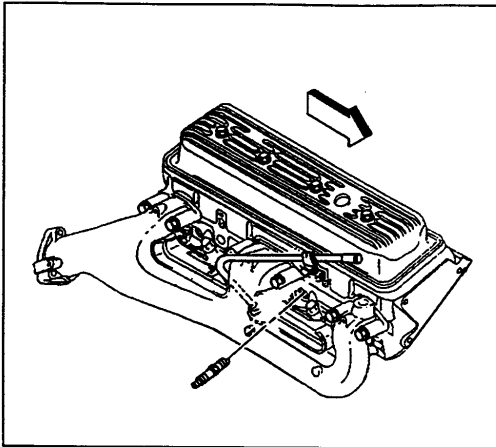
4. Install the bolt.

Tighten

Tighten the oil level indicator tube bolt to 12 N·m (106 lb in).



182831



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5. Install the spark plug for the number 4 cylinder.
6. Install the spark plug wire.

Tighten

Tighten the spark plug to 20 N.m (15 lb ft).

7. Install the air cleaner assembly.

SIE-ID - 348762

Engine Oil Pressure Sensor/Switch Replacement

Removal Procedure

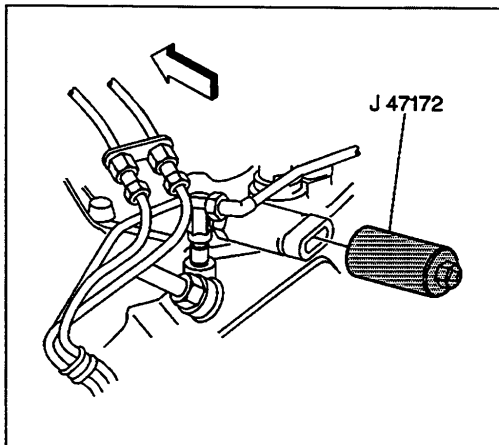
Tools Required

J 25254-10 A Oil Pressure Switch Socket.

1. Remove the Engine Cover. Refer to *Engine Cover Replacement (ERROR - NOT IN CURRENT PSD)* in Interior Trim.
2. Disconnect the electrical connector.
3. Hold the engine oil pressure sensor fitting with a wrench.

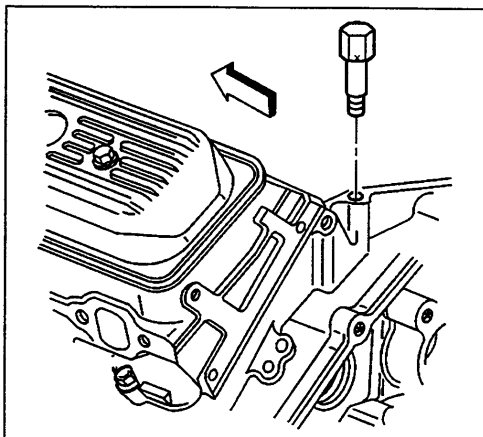
Important: Note the alignment of the oil pressure sensor fitting prior to removal.

4. Remove the engine oil pressure sensor using J 25254-10 A .



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5. Remove the engine oil pressure sensor fitting, if necessary.



333652

Installation Procedure

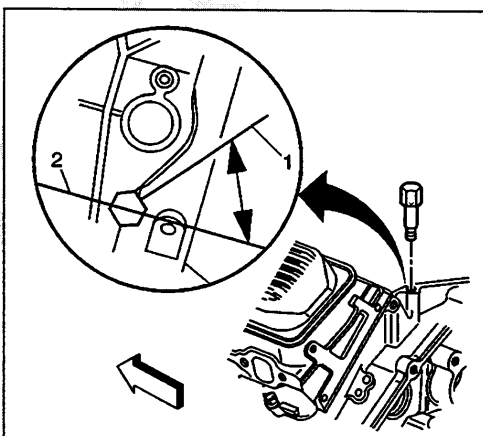
Notice: Fastener Notice in Cautions and Notices.

Important: Do not loosen the fitting. Do not tighten more than one turn.

1. Install the oil pressure sensor fitting, if removed.

Tighten

- 1.1. Tighten the engine oil pressure sensor fitting to 15 N·m (11 lb ft).
- 1.2. Tighten the fitting until properly align.



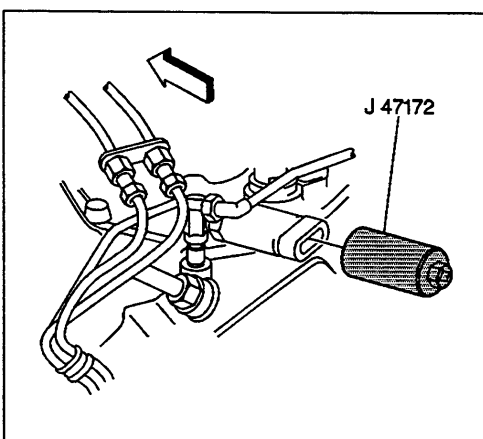
333659

2. Install the oil pressure sensor.
3. Hold the oil pressure sensor fitting with a wrench to prevent from turning.

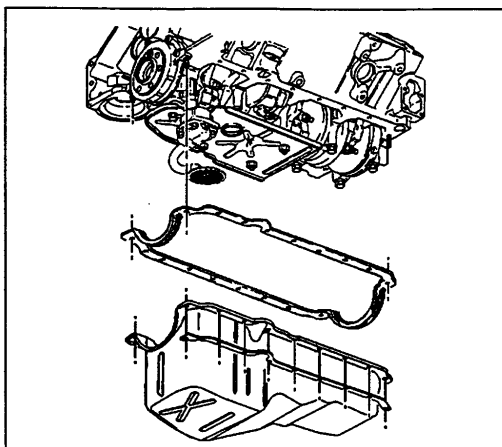
Tighten

Using J 25254-10 A tighten the oil pressure sensor to 30 N·m (22 lb ft).

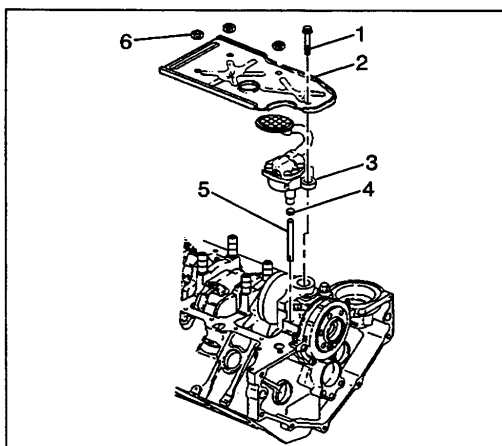
4. Install the electrical connector.
5. Install Engine Cover. Refer to *Engine Cover Replacement (ERROR - NOT IN CURRENT PSD)* in Interior Trim.



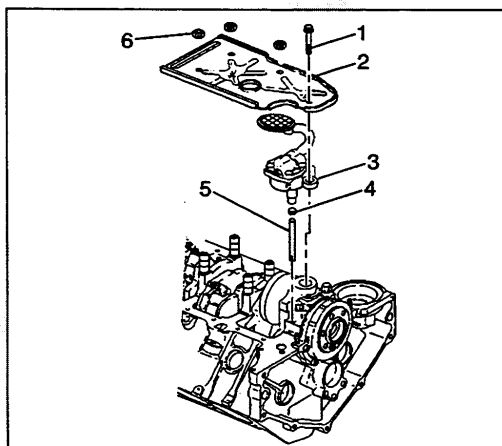
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SIE-ID - 332477

Oil Pump, Pump Screen and Deflector Replacement

Removal Procedure

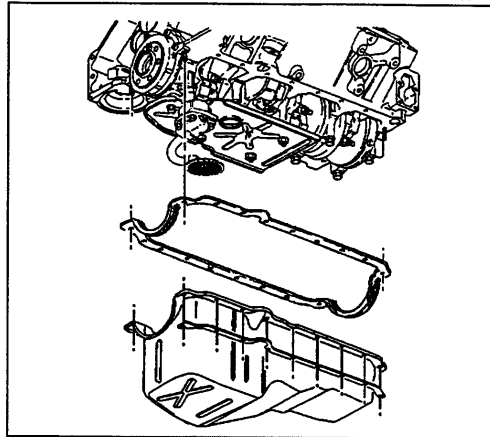
1. Remove the engine oil pan. Refer to *Oil Filter Adapter and Valve Assembly Replacement*.

2. Remove the oil pump.
3. A loose screen or pipe assembly can result in an air leak and loss of oil pressure. For more information, refer to *Oil Pump Clean and Inspect*.

Installation Procedure

1. Install the oil pump and the oil deflector.

2. Install the engine oil pan. Refer to *Oil Pan Replacement*.



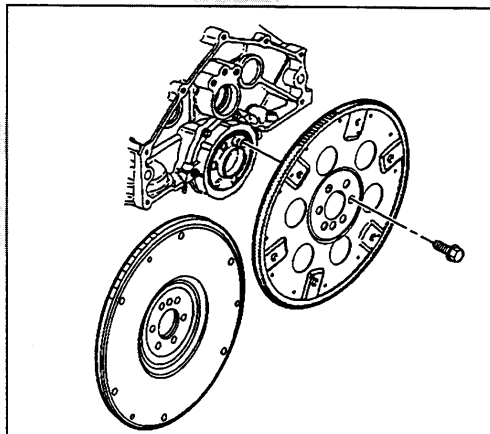
176052

SIE-ID - 332479

Crankshaft Rear Oil Seal and Housing Replacement (Housing)

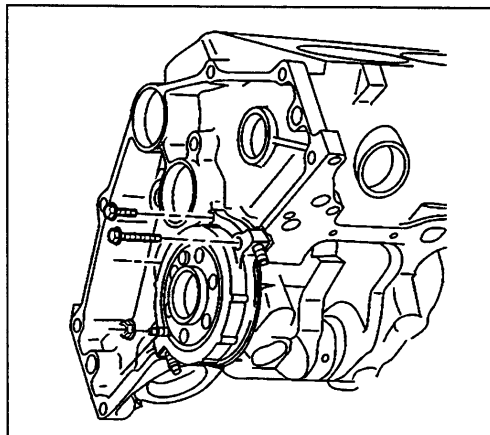
Removal Procedure

1. Remove the transmission assembly and the flywheel. Refer to *Transmission Replacement* in Transmission/Transaxle.

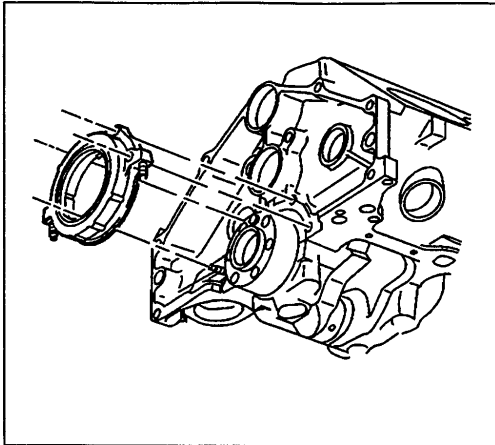


69012

2. Remove the following fasteners from the oil seal housing:
 - Three bolts using a T27 TORX® wrench and one nut.
 - Two lower studs using an E7 TORX® wrench.

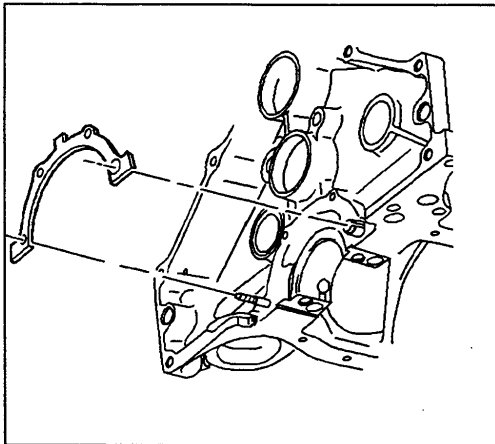


4071



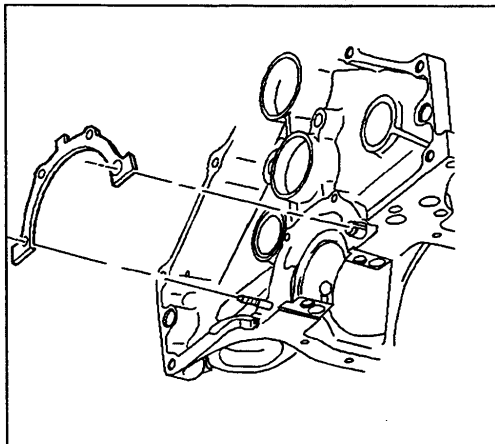
4072

3. Remove the crankshaft rear oil seal housing. Refer to *Crankshaft Rear Oil Seal and Housing Installation*.



4073

4. Remove the crankshaft rear oil seal housing gasket and discard.
5. Clean all the sealing surfaces.
6. Inspect the crankshaft rear oil seal housing housing for warping, cracks, wear, or damage.

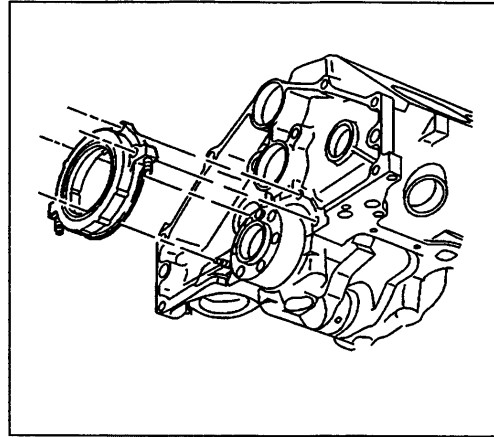


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Installation Procedure

1. Install a NEW crankshaft rear oil seal housing gasket.

2. Install the crankshaft rear oil seal housing to the engine block.



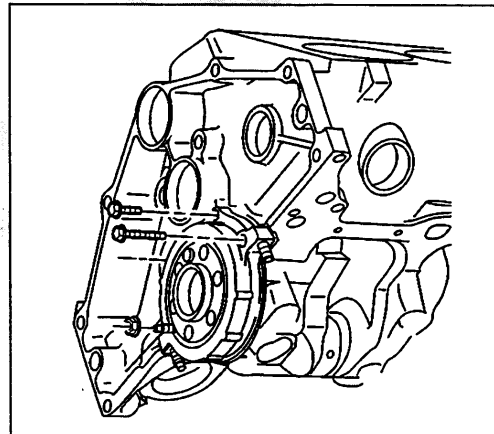
4072

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the following fasteners to the oil seal housing:
 - Three bolts using a T27 TORX® wrench and one nut.
 - Two lower studs using an E7 TORX® wrench, if needed.

Tighten

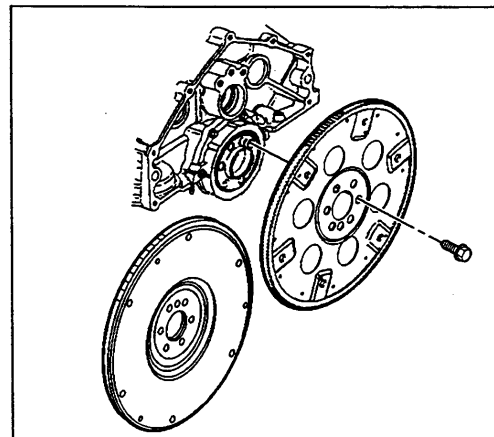
- Tighten the crankshaft rear oil seal housing bolts and nut to 12 N.m (106 lb in).
- Tighten the lower studs to 6 N.m (53 lb in), if needed.



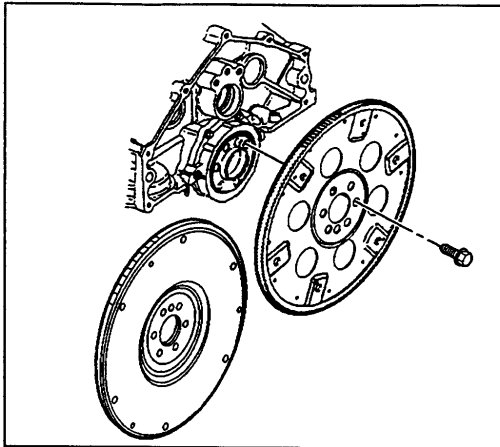
4071

4. Install the transmission assembly and the engine flywheel.

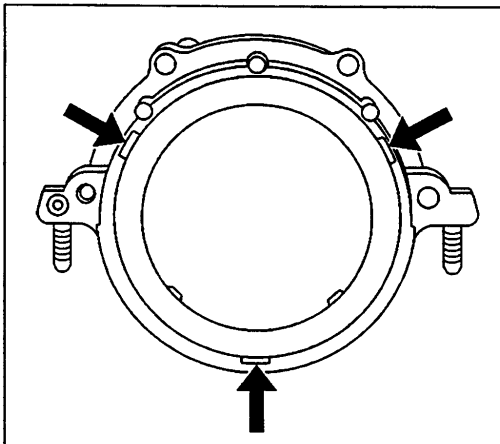
Refer to *Transmission Replacement* in Transmission/Transaxle.



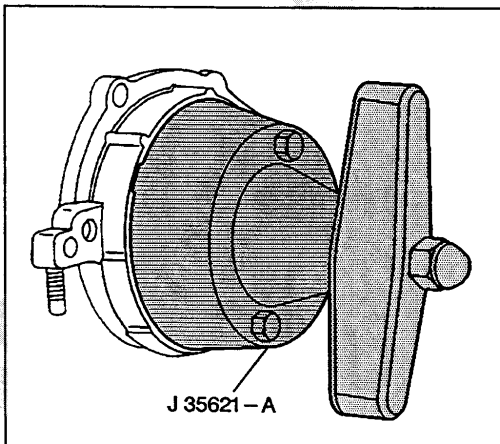
69012



69012



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23781

SIE-ID - 332482

Crankshaft Rear Oil Seal and Housing Replacement (Seal)

Removal Procedure

1. Remove the flywheel and transmission assembly. Refer to *Transmission Replacement* in Transmission/Transaxle.

2. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing. Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.
3. Discard the crankshaft rear oil seal.

Installation Procedure

Tools Required

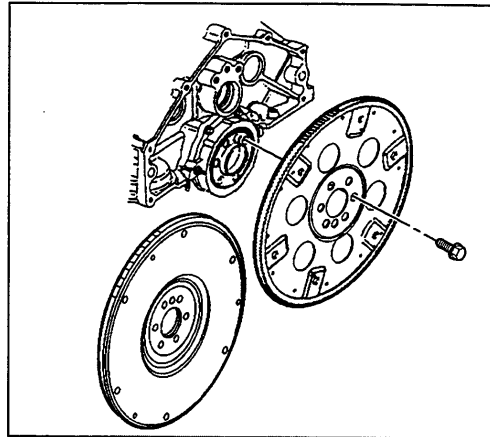
J 35621-A Crankshaft Rear Oil Seal Installer.

1. Use the J 35621-A in order to install the NEW oil seal.

Engine

Engine Mechanical - 5.0L, 5.7L 6-119

2. Install the engine flywheel and transmission assembly. Refer to *Transmission Replacement* in *Transmission/Transaxle*.

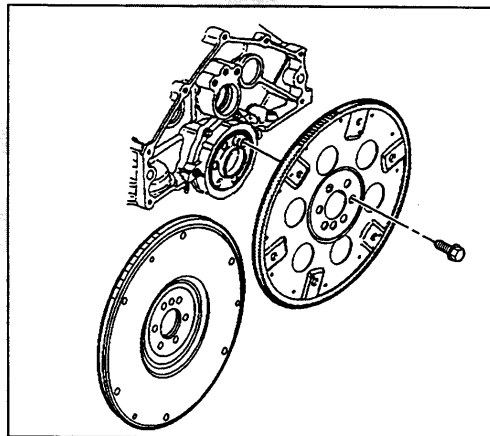


SIE-ID = 332483

Engine Flywheel Replacement (Manual Transmission)

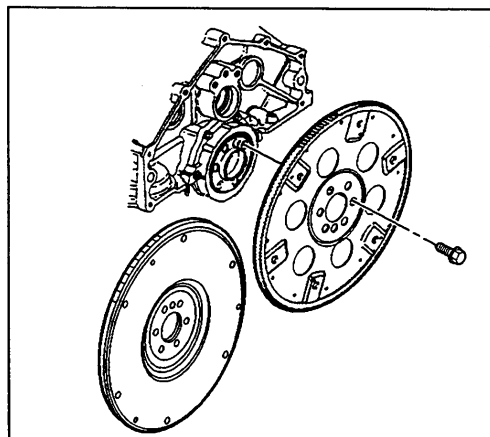
Removal Procedure

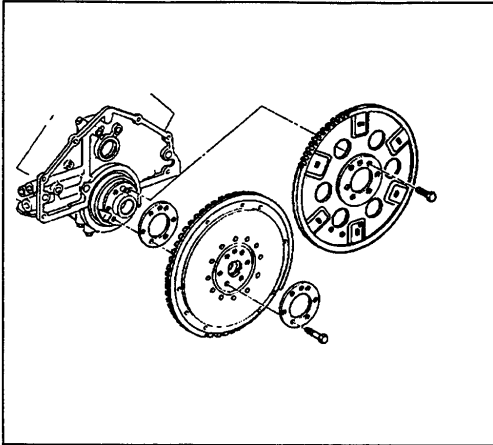
1. Remove the transmission and clutch assembly. Refer to *Transmission Replacement* in *Transmission/Transaxle*.
2. Remove the engine flywheel. Refer to *Engine Flywheel Removal*.
3. Clean and inspect all parts. Refer to *Engine Flywheel Clean and Inspect* (ERROR - NOT IN CURRENT PSD).



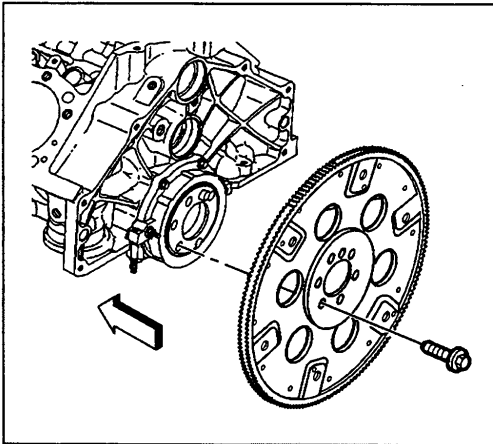
Installation Procedure

1. Install the engine flywheel.
2. Install the transmission and clutch assemblies. Refer to *Transmission Replacement* in *Transmission/Transaxle*.





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188130

SIE-ID = 332484

Engine Flywheel Replacement (Automatic Transmission)

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
2. Remove the engine flywheel. Refer to *Engine Flywheel Removal*.
3. Clean and inspect all parts. Refer to *Engine Flywheel Clean and Inspect* (ERROR - NOT IN CURRENT PSD).

Installation Procedure

1. Install the engine flywheel.
2. Install the transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.

SIE-ID = 332486

Engine Replacement

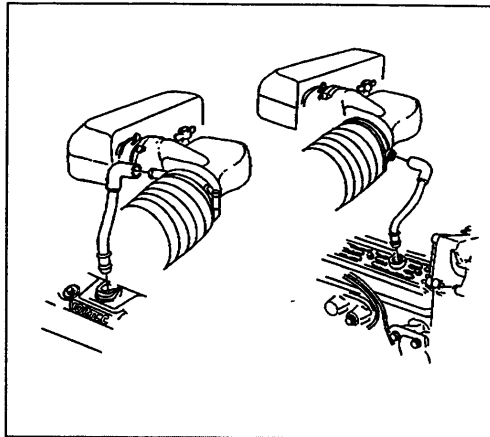
Removal Procedure

Tools Required

J 41427 Engine Lift Brackets

1. Disconnect the battery negative cable. Refer to *Battery Cable (0)* in engine electrical.
2. Remove the hood. Refer to *Hood Replacement*.

3. Remove the air cleaner assembly.
4. Drain the engine coolant. Refer to *Draining and Filling Cooling System*.
5. Remove the following coolant hoses:
 - Remove the upper radiator hose. Refer to *Radiator Hose Replacement (5.0L)* in Engine Cooling.
 - Remove the lower radiator hose. Refer to *Radiator Hose Replacement (6.5L)* in Engine Cooling.
 - Remove both heater hoses. Refer to *Heater Hoses Replacement (Inlet Hose - 5.0L, 5.7L, 7.4L)* and *Heater Hoses Replacement (Outlet Hose - 5.0L, 5.7L)*.
6. Remove the upper radiator shroud. Refer to *Fan Shroud Replacement (Upper)* and *Fan Shroud Replacement (Lower)* in Engine Cooling.

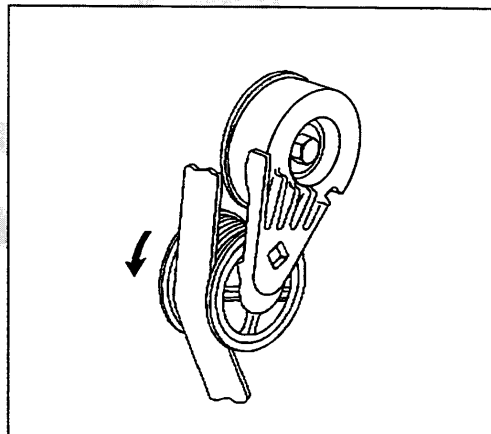


173191

7. Remove the drive belt. Refer to *Drive Belt Replacement*.

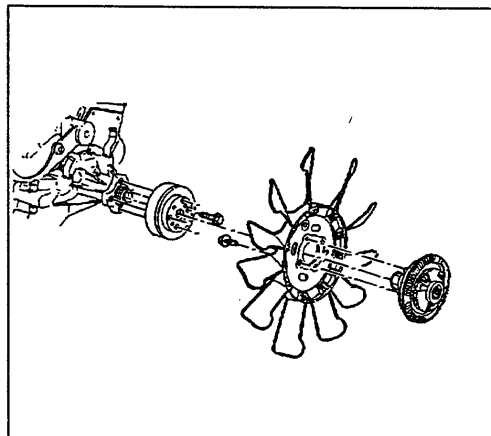
Caution: SIO-ID - 352518 *To help avoid potential personal injury or potential damage to the vehicle due to possible cable damage during service, replace the existing accelerator control cable with a NEW cable when removing or replacing the engine. Position the cruise control cable out of the way to ensure it is not damaged while removing or installing the engine. Do not bend the cruise control cable and cause a kink at the bend. Do not position the cruise control cable where the technician may lean or pry against the cable and cause damage to the cable.*

8. Disconnect the accelerator control cable and the cruise control cable, if equipped. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.

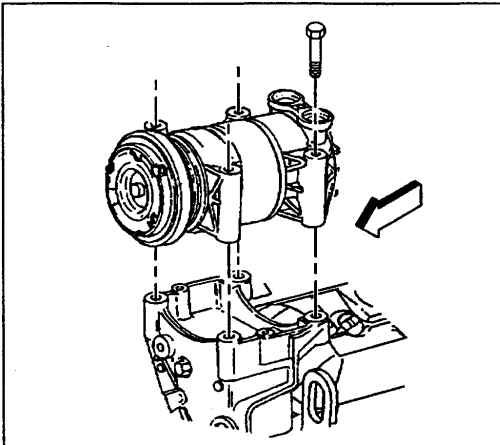


177620

9. Remove the engine cooling fan. Refer to *Fan Clutch Replacement (5.0L, 5.7L and 6.5L)*.



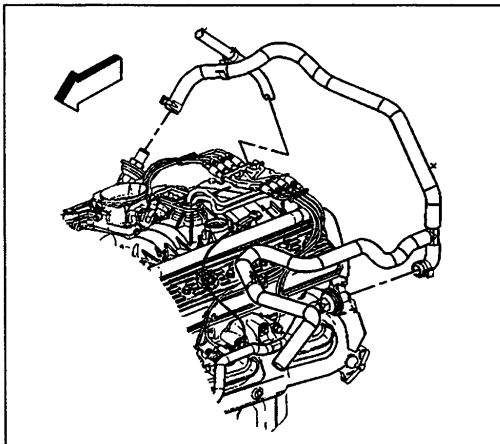
107967



179249

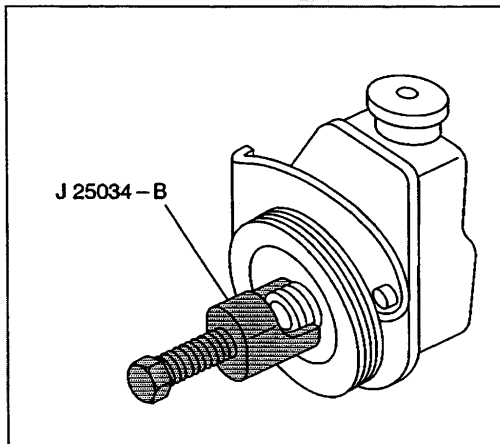
Important: It is not necessary to discharge the A/C refrigerant.

10. Remove the air conditioning compressor, if equipped, and set it aside. Refer to *Compressor Replacement (5.0L, 5.7L)* in HVAC.



341228

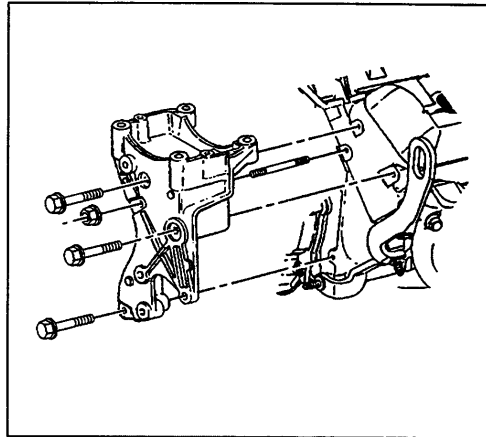
11. Remove AIR bypass hose assembly, if so equipped. Refer to *Sec Air Injection Check Valve/Pipe Replacement*.



188649

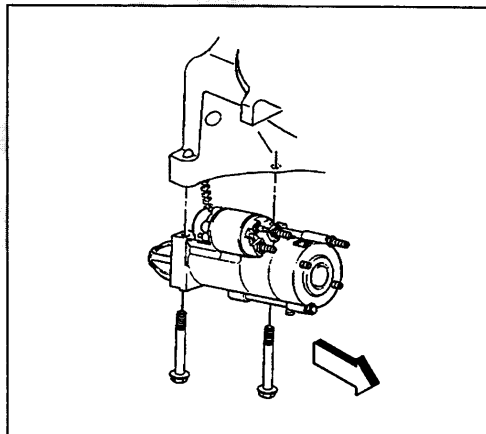
12. Remove the power steering pump pulley. Refer to *Power Steering Pump Replacement (5.0L, 5.7L)*.

13. Remove the power steering pump mounting bracket using the following procedure:
 - 13.1. Disconnect the electrical connector from the power steering pump.
 - 13.2. Remove the nuts holding the power steering pump to the engine.
 - 13.3. Remove the power steering pump mounting bracket bolts and the nut.
 - 13.4. Slide the power steering pump mounting bracket forward with the power steering pump still attached.
 - 13.5. Remove the stud from the cylinder head.
 - 13.6. Set the power steering pump and the mounting bracket aside.



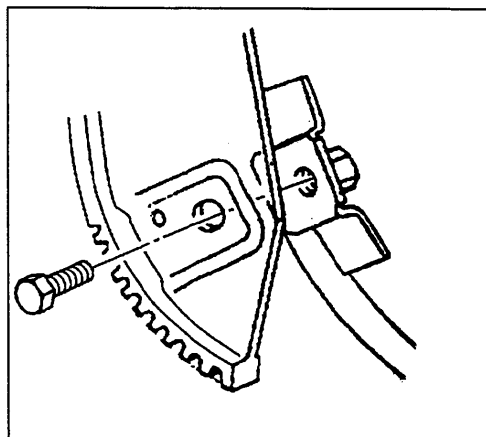
188295

14. Remove the starter motor. Refer to *Starter Motor Replacement (ERROR - NOT IN CURRENT PSD)*.
15. Remove the starter opening cover.
16. Disconnect the electrical connectors on the top of the engine.
17. Disconnect the positive battery cable at the generator.

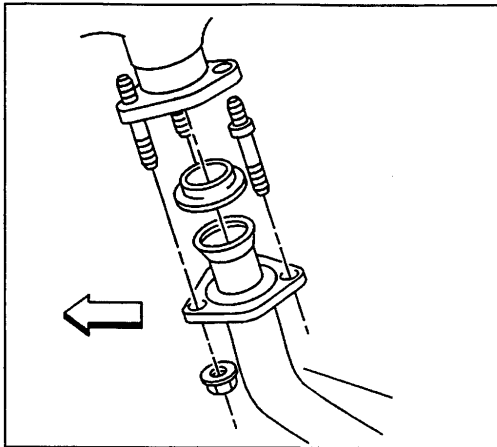


183406

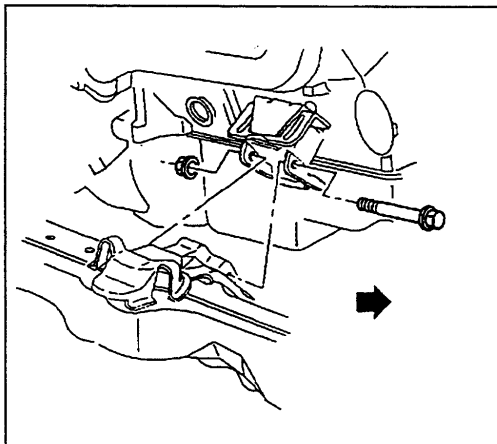
18. Remove the torque converter to flywheel bolts. Refer to *Flywheel to Torque Converter Bolts (ERROR - NOT IN CURRENT PSD)* in automatic transmission, transaxle.
19. Disconnect the transmission cooler pipe bracket from the right side of the oil pan. Refer to *Oil Cooler Line Replacement* in automatic transmission, transaxle.



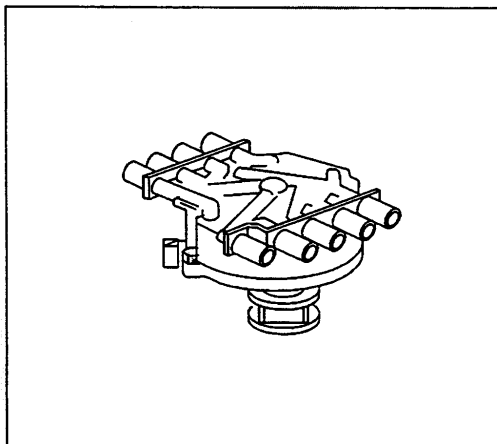
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4564



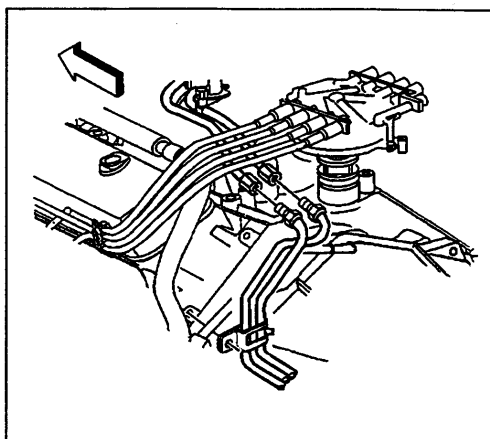
344232

20. Remove the exhaust pipe from the exhaust manifolds. Refer to *Exhaust Manifold Pipe Replacement (Diesel)* in Engine Exhaust.
21. Support the transmission with a suitable strap.
22. Remove the engine oil cooler pipes, if equipped. Refer to *Engine Oil Cooler Line Replacement*.
23. Remove both engine mount through-bolts.
24. Remove seven transmission to engine bolts including the brackets.
25. Lower the vehicle.
26. Disconnect the remaining electrical connectors.
27. Remove the distributor cap. Refer to *Distributor Replacement (ERROR - NOT IN CURRENT PSD)*.
28. Remove the engine harness support.

Engine

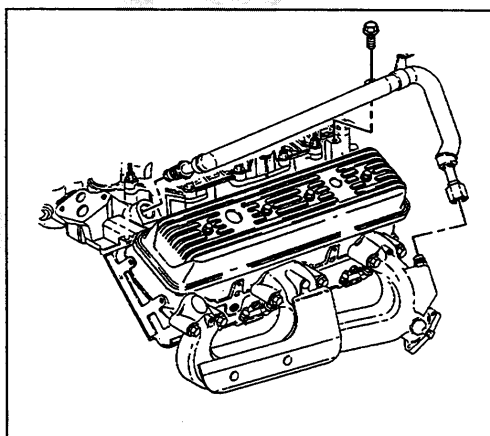
Engine Mechanical - 5.0L, 5.7L 6-125

29. Disconnect the fuel pipes. Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.
30. Remove two transmission to engine bolts at the rear top of the engine.



343625

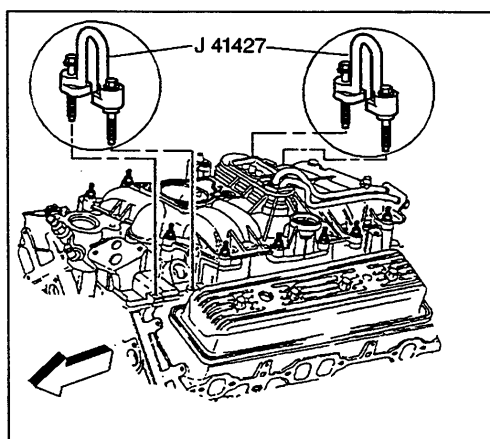
31. Remove the EGR pipe. Refer to *Sec Air Injection Check Valve/Pipe Replacement* in Engine Controls.



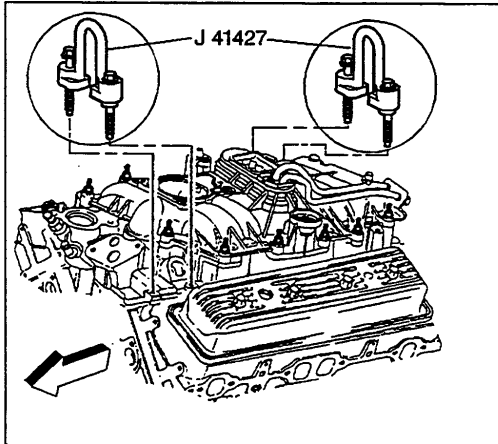
173206

Notice: Refer to *Fastener Notice* in Cautions and Notices.

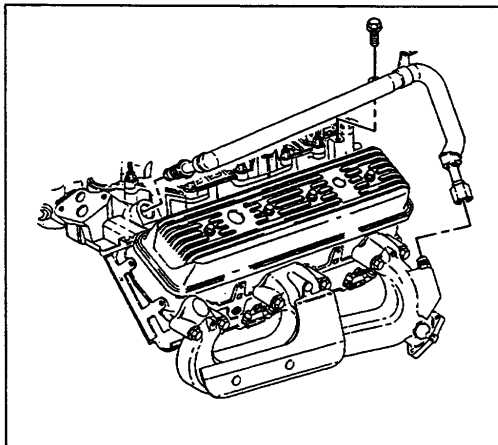
32. Attach the J 41427 to the left front and right rear intake manifold mounting bolts, using the following procedure:
 - 32.1. Remove the right rear lower intake manifold bolts. Refer to *Intake Manifold Replacement (Lower)*.
 - 32.2. Install the J 41427 marked RIGHT REAR.
 - 32.3. Install the retaining bolts.
Tighten
Tighten the bolts to 15 N.m (11 lb ft).
 - 32.4. Remove the left front lower intake manifold bolts.
 - 32.5. Install the J 41427 marked LEFT FRONT with the arrow pointing to the front of the engine.
 - 32.6. Install the retaining bolts.



66496



66496



173206

Tighten

Tighten the bolts to 15 N.m (11 lb ft).

33. Attach a suitable lifting device to the lift brackets.
34. Remove the engine.

Installation Procedure**Tools Required****J 41427 Engine Lift Brackets**

1. Install the engine in the vehicle.
2. Install two top transmission to engine bolts, including the brackets and clips.
3. Remove the J 41427 and the lifting device.
4. Apply thread lock GM P/N 12345382 or equivalent to the threads of the lower intake manifold bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Reinstall the intake manifold bolts.

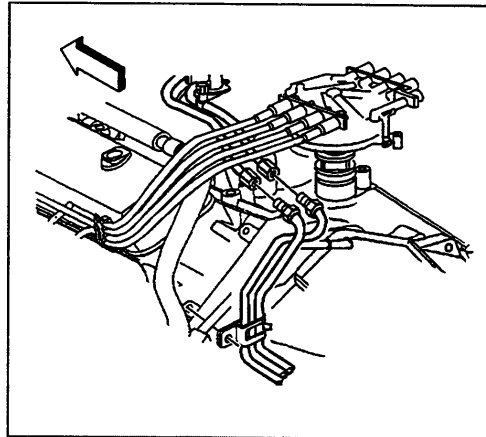
Tighten

- 5.1. Tighten the bolts on the first pass to 3 N.m (27 lb in).
- 5.2. Tighten the bolts on the second pass to 12 N.m (106 lb in).
- 5.3. Tighten the bolts on the third pass to 15 N.m (11 lb ft).
6. Install the EGR valve inlet pipe. Refer to *Sec Air Injection Check Valve/Pipe Replacement* in Engine Controls.

Engine

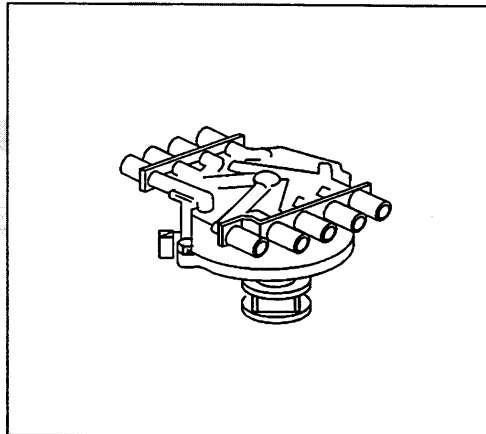
Engine Mechanical - 5.0L, 5.7L 6-127

7. Connect the fuel pipes.
Refer to *Fuel Hose/Pipes Assembly Replacement (Fuel Pipes)* in Engine Controls.
8. Install the engine harness support.



343625

9. Install the distributor cap. Refer to *Distributor Replacement (ERROR - NOT IN CURRENT PSD)*.

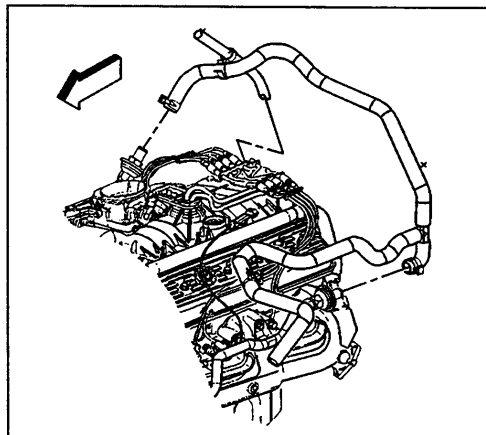


344232

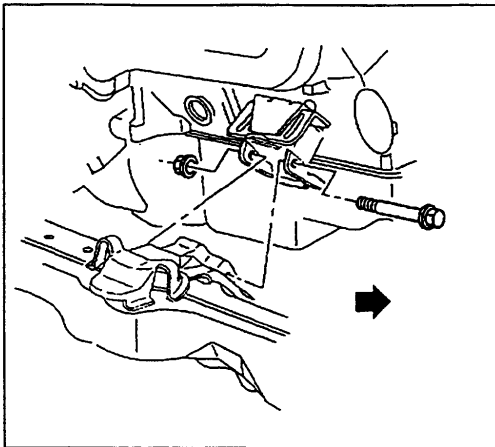
10. Install the AIR bypass hose assembly, if equipped. Refer to *Sec Air Injection Check Valve/Pipe Replacement*.
11. Connect the engine harness.
12. Install the remaining seven transmission to engine bolts.

Tighten

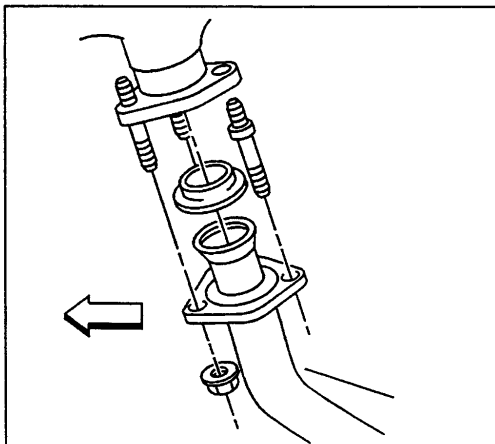
Tighten the bolts to 100 N.m (74 lb ft).



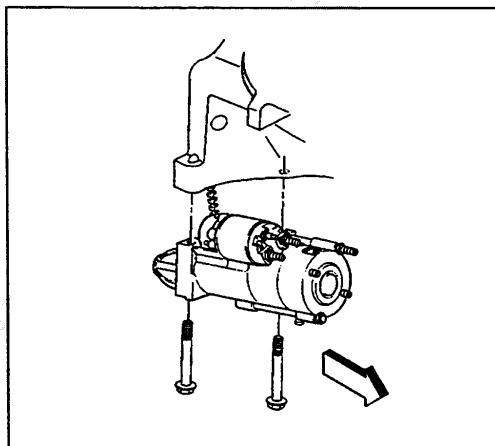
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183406

13. Install both engine mount through-bolts, if equipped. Refer to *Engine Mount Replacement (Front C Model)*.
14. Install the oil cooler pipes, if equipped.
15. Remove the transmission support strap.

16. Install the exhaust pipe to the exhaust manifolds. Refer to *Engine Oil Cooler Line Replacement* in Engine Exhaust.
17. Install the transmission cooler pipe bracket to the right side of the oil pan, if equipped.
18. Install three torque converter to engine flywheel bolts, if equipped.

Tighten

Tighten the bolts to 75 N·m (55 lb ft).

19. Install the starter opening shield.
20. Install the starter motor. Refer to *Starter Motor Replacement (ERROR - NOT IN CURRENT PSD)*.
21. Connect the positive battery cable at the generator.

Tighten

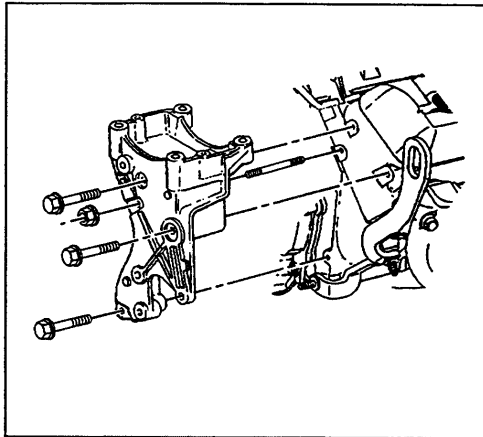
Tighten the nut to 20 N·m (15 lb in).

22. Connect the engine harness to the top of the engine.

23. Install the power steering pump mounting bracket using the following procedure:
- 23.1. Loosely assemble the mounting bracket over the stud.
 - 23.2. Install a nut to the stud finger tight.
 - 23.3. Install the three bolts finger tight.
 - 23.4. Install the two nuts to the power steering pump finger tight.

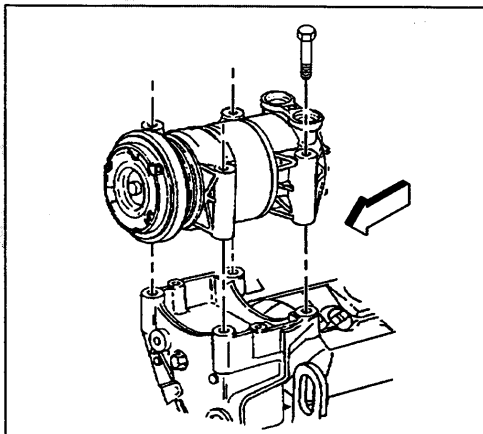
Tighten

Tighten the nuts and bolts to 41 N.m (30 lb ft).



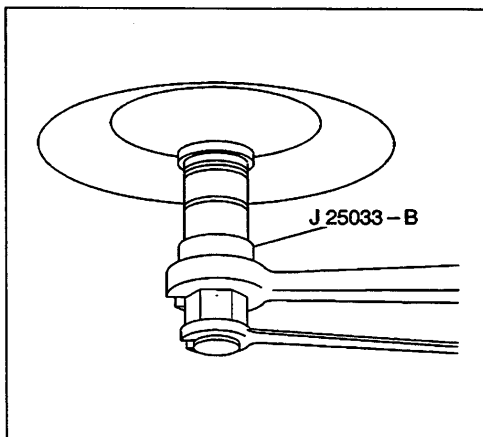
188295

24. Install the air conditioning (A/C) compressor, if equipped. Refer to *Compressor Replacement (5.0L, 5.7L)*.
25. Connect the electrical connector to the power steering pump.

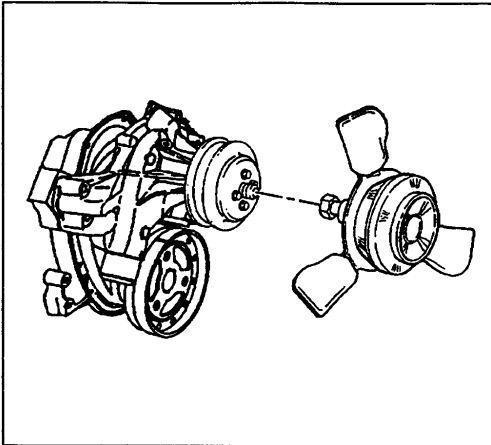


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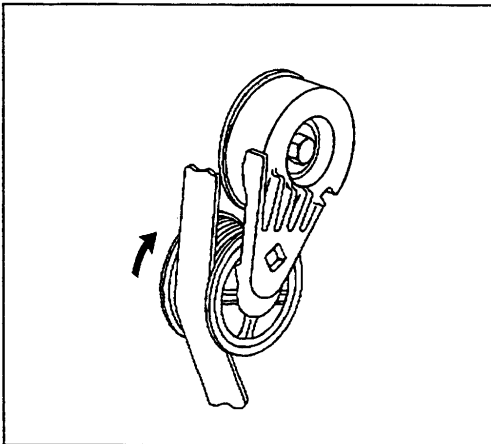
26. Use the *J 25033-B* in order to install the power steering pump pulley. Refer to *Power Steering Pump Replacement (5.0L, 5.7L)*.



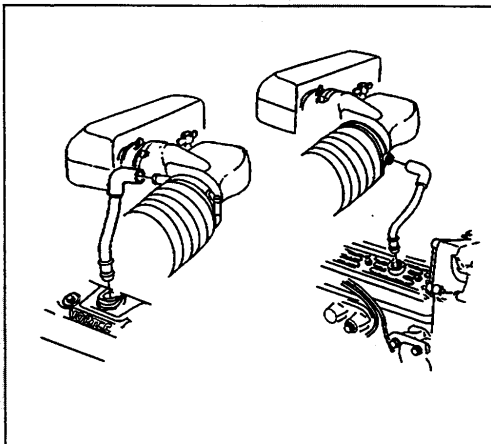
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188352



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173191

27. Install the engine cooling fan. Refer to *Fan Clutch Replacement (ERROR - NOT IN CURRENT PSD)*.

28. Install the drive belt. Refer to *Drive Belt Replacement*.

Caution: SIO-ID - 352518 To help avoid potential personal injury or potential damage to the vehicle due to possible cable damage during service, replace the existing accelerator control cable with a NEW cable when removing or replacing the engine. Position the cruise control cable out of the way to ensure it is not damaged while removing or installing the engine. Do not bend the cruise control cable and cause a kink at the bend. Do not position the cruise control cable where the technician may lean or pry against the cable and cause damage to the cable.

29. Connect the NEW accelerator control cable and the cruise control cable, if equipped. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
30. Install the air cleaner assembly.
31. Install the upper radiator shroud. Refer to *Fan Shroud Replacement (Upper)* and *Fan Shroud Replacement (Lower)* in Engine Cooling.
32. Install the following coolant hoses:
- The upper radiator hose. Refer to *Radiator Hose Replacement (5.0L)* in Engine Cooling.
 - The lower radiator hose. Refer to *Radiator Hose Replacement (6.5L)* in Engine Cooling.
 - Both heater hoses. Refer to *Heater Hoses Replacement (Inlet Hose - 5.0L, 5.7L, 7.4L)* and *Heater Hoses Replacement (Outlet Hose - 5.0L, 5.7L)*.
33. Fill the cooling system with coolant. Refer to *Draining and Filling Cooling System (ERROR - NOT IN CURRENT PSD)*.
34. Install the hood. Refer to *Hood Replacement*.
35. Connect the battery negative cable. Refer to *Battery Cable (0)* in Engine Electrical.

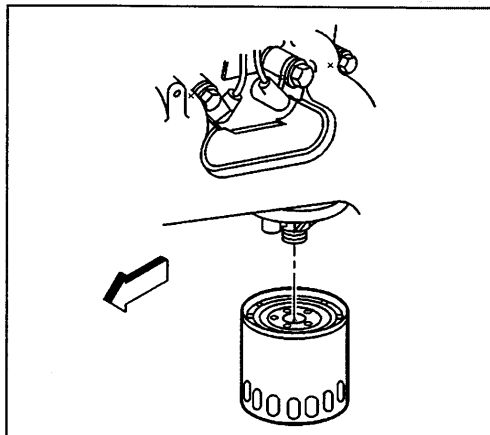
36. Before starting a new engine, or one that has been repaired. Refer to *Engine Set-Up and Testing*.

SIE-ID = 332487

Engine Oil and Oil Filter Replacement

Removal Procedure

1. Open the hood.
2. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the oil filter from the engine block.
4. Remove the oil pan drain plug and drain the engine oil into a suitable container.

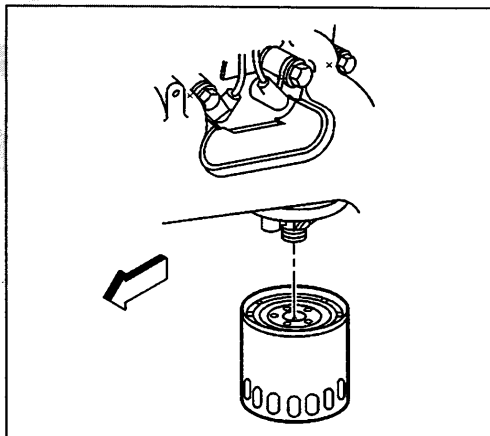


316766

Installation Procedure

Caution: Refer to *Battery Disconnect Caution in Cautions and Notices*.

1. Install the NEW oil filter to the engine block.
Tighten
Tighten the oil filter to 37 N.m(27 lb ft).
2. Install the oil pan drain plug to the oil pan.
Tighten
Tighten the oil pan drain plug to 25 N.m(18 lb ft).
3. Remove the safety stands and lower the vehicle. Refer to *Vehicle Lifting and Jacking* in General Information.
4. Fill the crankcase with oil. Refer to *Fluid and Lubricant Recommendations* in General Information.
5. Close the hood.

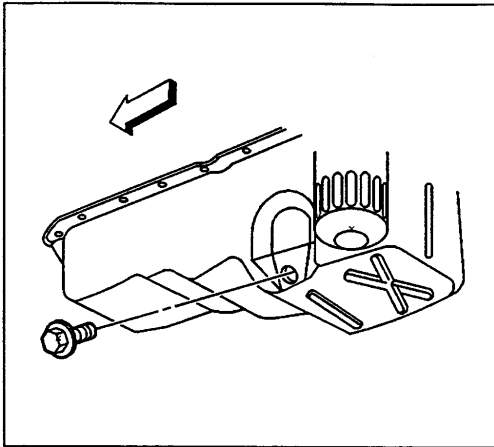


316766

SIE-ID - 194572

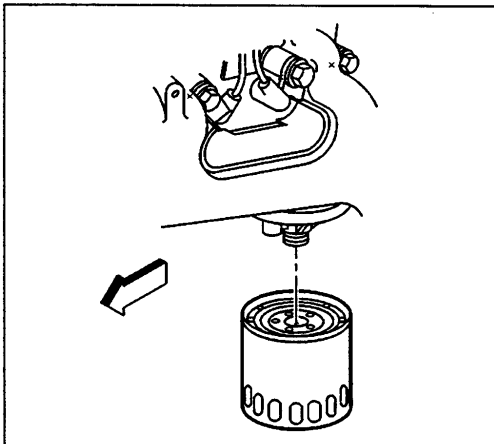
Draining Fluids and Oil Filter Removal

1. Remove the oil pan drain plug. Allow the oil to drain.



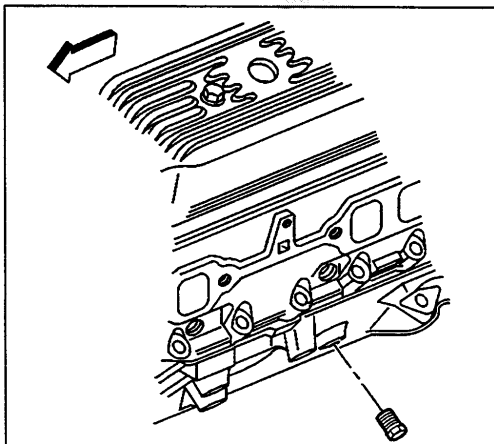
182850

2. Remove the oil filter.



316766

3. Remove the engine block coolant drain hole plug.



316798

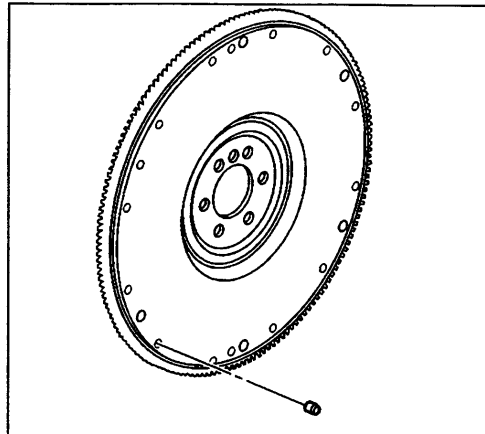
SIE-ID = 66678

Engine Flywheel Removal

SIO-ID = 66954

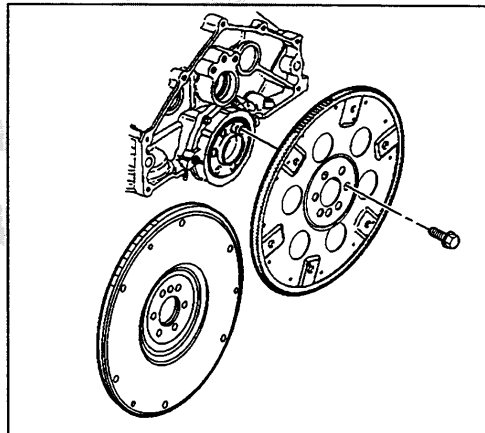
Important: If replacing the manual transmission type engine flywheel, note the location of any existing flywheel weights (if applicable). Install new flywheel weights into the new engine flywheel (if applicable). Flywheel weights must be installed into the new engine flywheel in the same location as the old flywheel weights in the old engine flywheel. A properly installed flywheel weight will be either flush or below flush with the face of the engine flywheel.

1. Note the position and location of the flywheel weights (if applicable).



64126

2. Remove the engine flywheel bolts.
3. Remove the engine flywheel.



69012

SIE-ID = 375497

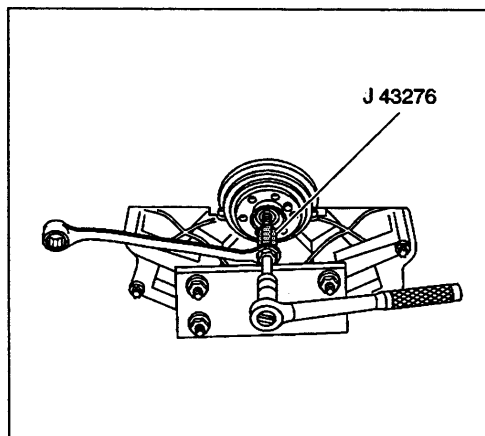
Clutch Pilot Bearing Removal**Tools Required**

J 43276 Clutch Pilot Bearing Remover

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

Notice: SIO-ID = 352829 When using the J 43276 Clutch Pilot Bearing Remover always secure the J 43276-1 Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the J 43276-1 Clutch Pilot Bearing Remover tool body to rotate. Failing to do so will cause damage to the J 43276-1 Clutch Pilot Bearing Remover tool body.

1. Remove the clutch pilot bearing using the J 43276 .
 - 1.1. Install the J 43276-1 tool body into the clutch pilot bearing.
 - 1.2. Using a wrench secure the J 43276-1 tool body.



373133

- 1.3. Insert the J 43276-2 forcing screw into the J 43276-1 tool body.
- 1.4. Rotate the J 43276-2 forcing screw clockwise into the J 43276-1 tool body until the clutch pilot bearing is completely removed from the crankshaft.
- 1.5. Rotate the J 43276-2 forcing screw counterclockwise to remove the J 43276-2 forcing screw from the J 43276-1 tool body.
- 1.6. Remove the J 43276-1 tool body from the clutch pilot bearing.
2. Discard the clutch pilot bearing.

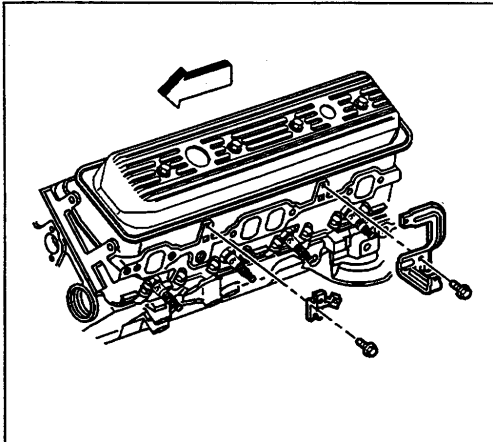
SIE-ID = 67244

Exhaust Manifold Removal (Left)

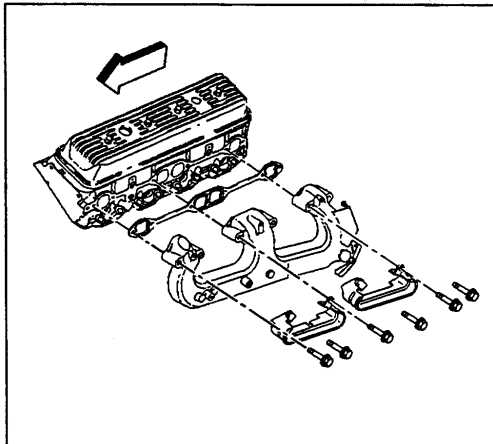
SIO-ID = 66885

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 - 1.1. Rotate the spark plug wire boot one half turn.
 - 1.2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the bolts and the spark plug wire supports.
3. Remove the exhaust manifold bolts.
4. Remove the spark plug wire shields.
5. Remove the exhaust manifold.
6. Remove and discard the exhaust manifold gasket.



317185



64925

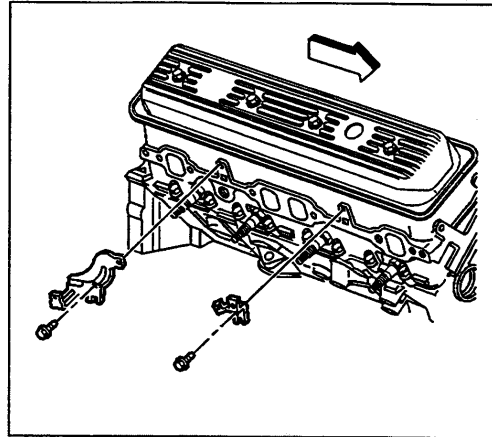
SIE-ID = 66680

Exhaust Manifold Removal (Right)

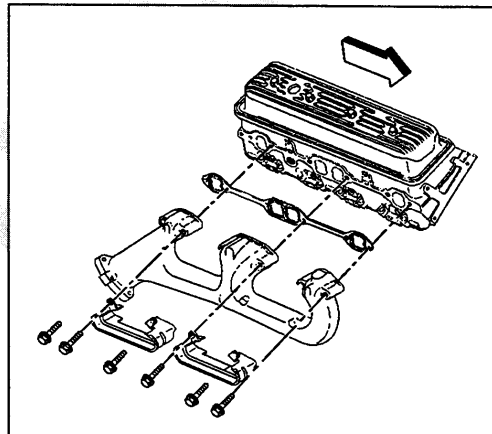
SIO-ID = 66894

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 - 1.1. Rotate the spark plug wire boot one half turn.
 - 1.2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the bolts and the spark plug wire supports.
3. Remove the exhaust manifold bolts.
4. Remove the spark plug wire shields.
5. Remove the exhaust manifold.
6. Remove and discard the exhaust manifold gasket.



317179

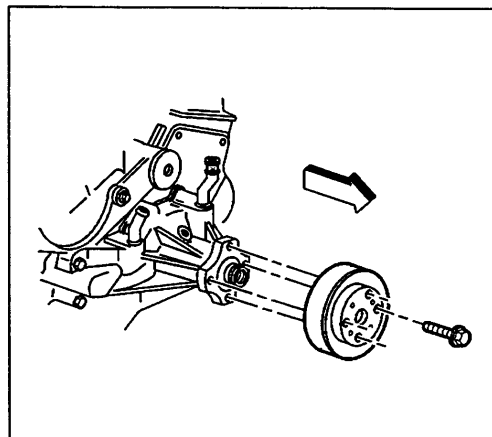


69032

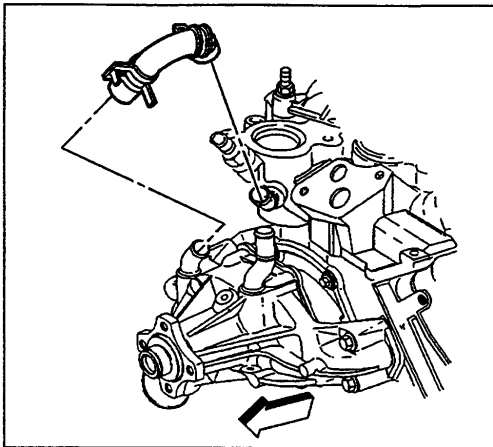
SIE-ID = 69041

Water Pump Removal

1. Remove the bolts and the fan and water pump pulley.

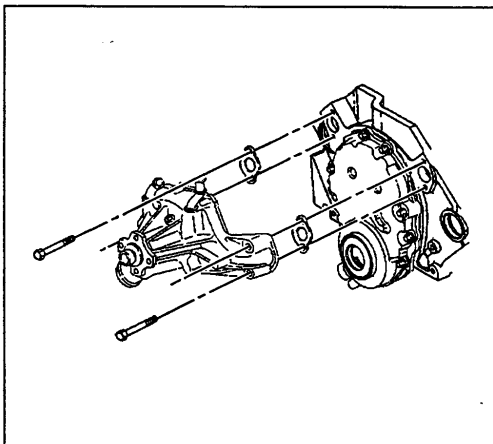


317191



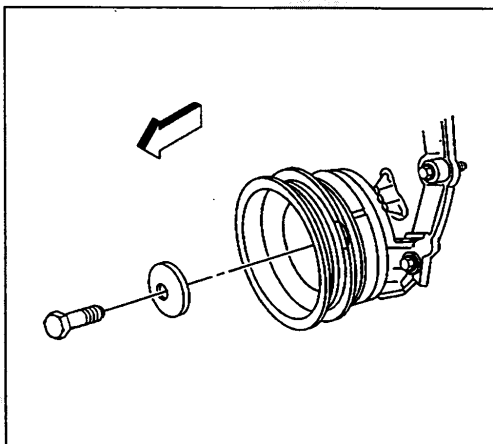
182853

2. Remove the clamps and the water pump inlet hose.



69011

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gaskets.
6. Discard the water pump gaskets.



173172

SIE-ID = 66682

Crankshaft Balancer Removal

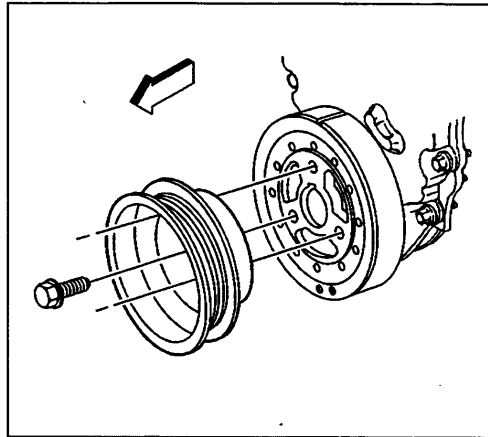
SIO-ID = 66889

Tools Required

J 23523-F Balancer Remover and Installer

1. Remove the crankshaft balancer bolt and washer.

2. Remove the bolts and the crankshaft pulley.

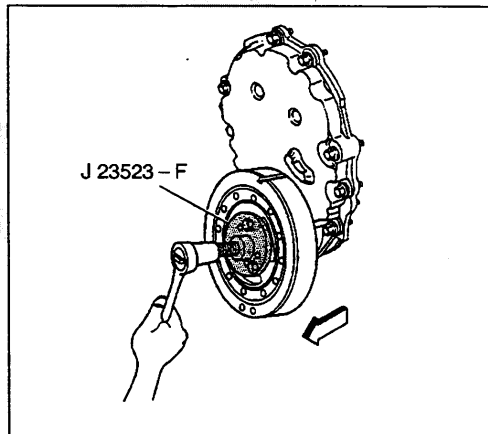


188055

Notice: *SIO-ID - 301560* To prevent damage to the end of the crankshaft when using a crankshaft balancer removal tool install a bolt in the crankshaft. Use a shorter bolt with the same threads as the crankshaft balancer bolt. This bolt will allow a place for the tool to push against. The shorter bolt is to keep from going past the threads in the crankshaft and damaging the crankshaft threads.

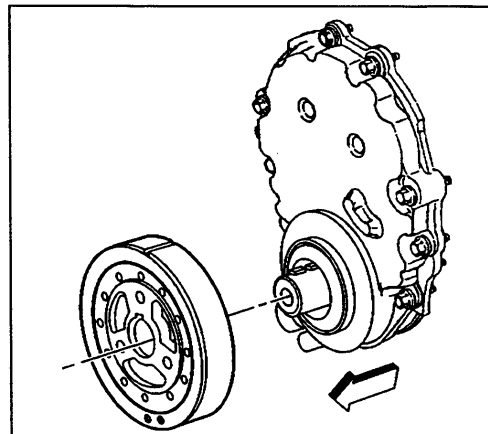
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Use the *J 23523-F* in order to remove the crankshaft balancer.
 - 3.1. Install the *J 23523-F* plate and bolts.
Tighten
Tighten the bolts to 25 N.m (18 lb ft).
 - 3.2. Install the *J 23523-F* forcing screw.
 - 3.3. Rotate the *J 23523-F* forcing screw clockwise in order to remove the crankshaft balancer.

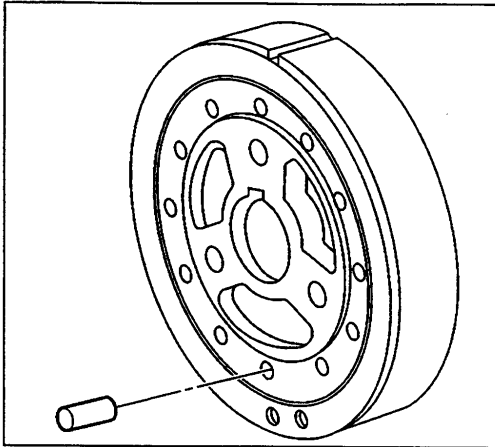


66878

4. Remove the crankshaft balancer.
5. Remove the *J 23523-F* from the crankshaft balancer.

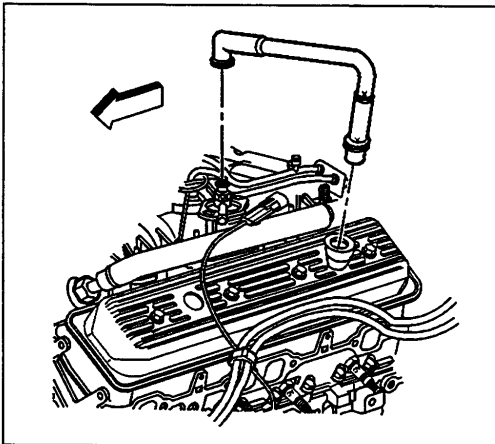


182832



182849

6. Note the position of any front groove pins (crankshaft balancer weights) (if applicable).

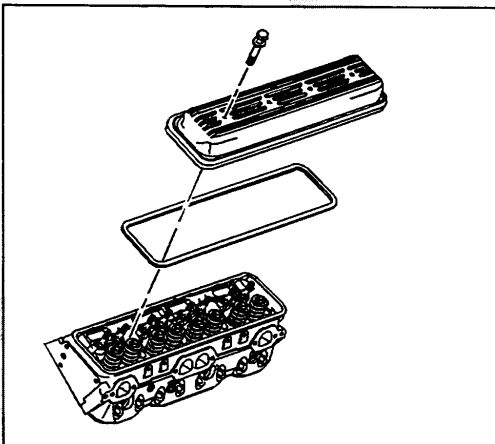


317197

SIE-ID = 39120

Valve Rocker Arm Cover Removal (Left)

1. Remove the PCV valve hose assembly.



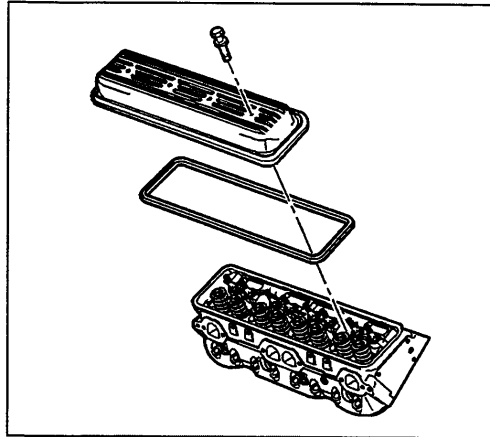
39119

2. Remove the valve rocker arm cover bolts and washers.
3. Remove the valve rocker arm cover.
4. Remove the valve rocker arm cover gasket.
5. Discard the valve rocker arm cover gasket.

SIE-ID = 194614

Valve Rocker Arm Cover Removal (Right)

1. Remove the valve rocker arm cover bolts and washers.
2. Remove the valve rocker arm cover.
3. Remove the valve rocker arm cover gasket.
4. Discard the valve rocker arm cover gasket.

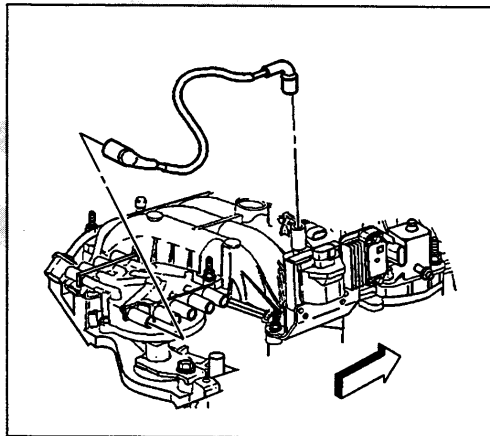


182633

SIE-ID = 69504

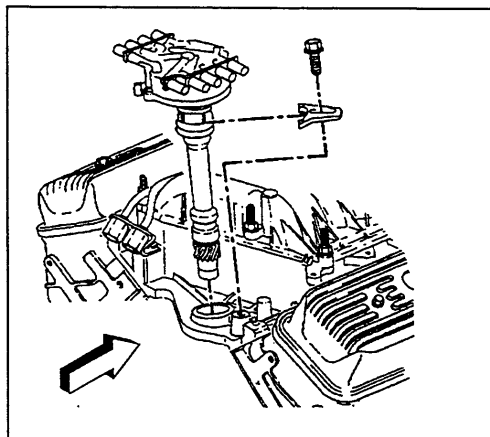
Distributor Removal

1. Remove the ignition coil wire harness from the ignition coil and distributor cap.

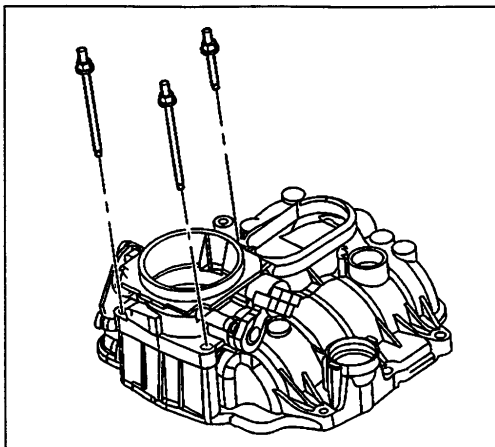


341359

2. Remove the distributor clamp bolt.
3. Remove the distributor clamp.
4. Remove the distributor.



69303

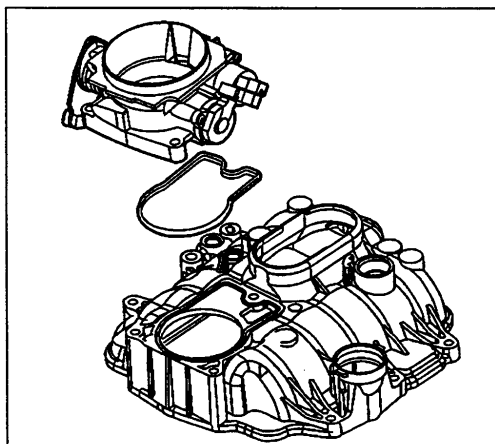


12852

SIE-ID = 194657

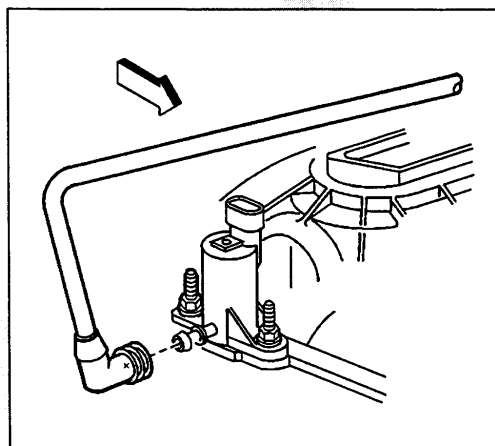
Throttle Body Removal

1. Remove the throttle body attaching studs.



12853

2. Remove the throttle body.
3. Remove the throttle body gasket.
4. Discard the throttle body gasket.



317211

SIE-ID = 66685

Intake Manifold Removal

SIO-ID = 67830

1. Remove the evaporative emission canister purge solenoid valve harness.
 - 1.1. Push the quick disconnect clip and hold in place.
 - 1.2. Pull outward on the harness elbow.

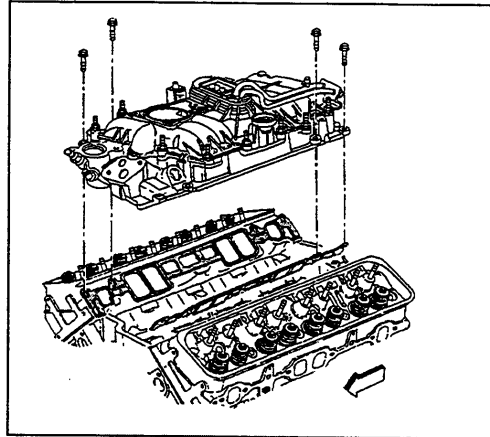
2. Remove the lower intake manifold bolts.

Important: The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless component service is required.

Do not allow dirt or debris to enter the fuel system. Ensure that the ends of the fuel system are properly sealed.

Do not disassemble the Central Sequential Fuel Injection (SFI) unit, unless service is required.

3. Remove the intake manifold assembly.
4. Remove and discard the lower intake manifold gaskets.



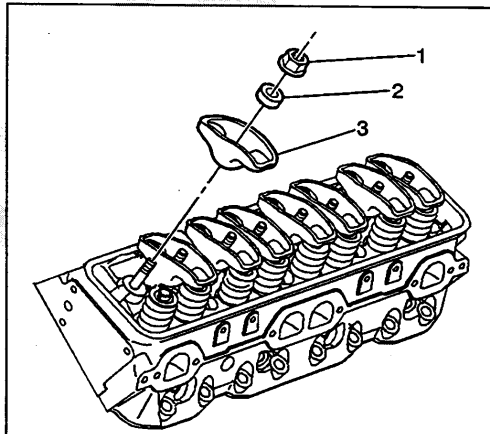
66456

SIE-ID = 66690

Valve Rocker Arm and Push Rod Removal

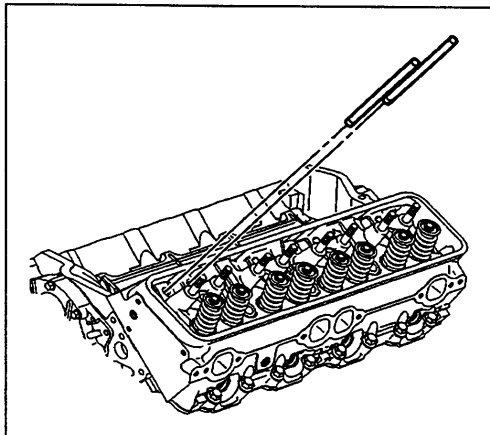
Important: Mark, sort, and organize the components so that the components can be reinstalled to the original location.

1. Remove the following components from the cylinder head:
 - 1.1. The valve rocker arm nuts (1)
 - 1.2. The valve rocker arm balls (2)
 - 1.3. The valve rocker arms (3)

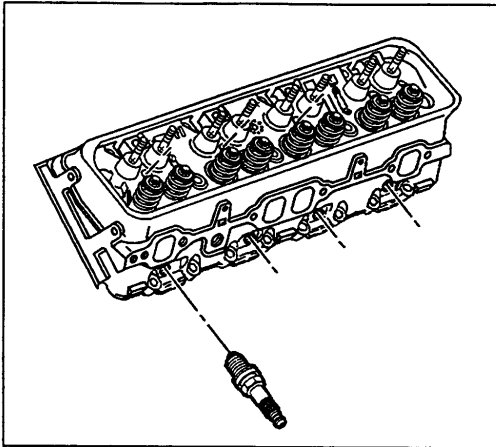


182635

2. Remove the valve pushrods.



22766

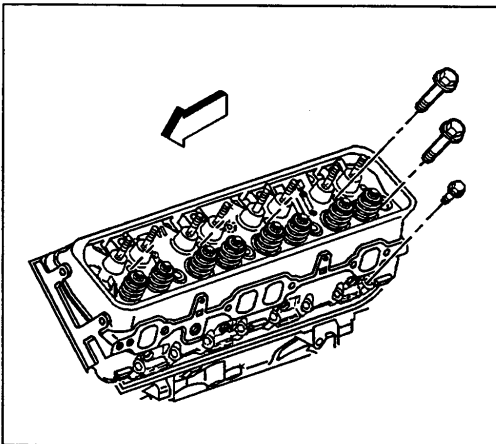


SIE-ID = 66692

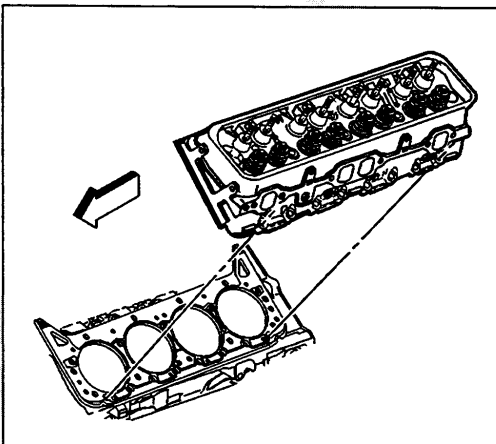
Cylinder Head Removal (Left)

SIO-ID = 66888

1. Remove and discard the spark plugs.



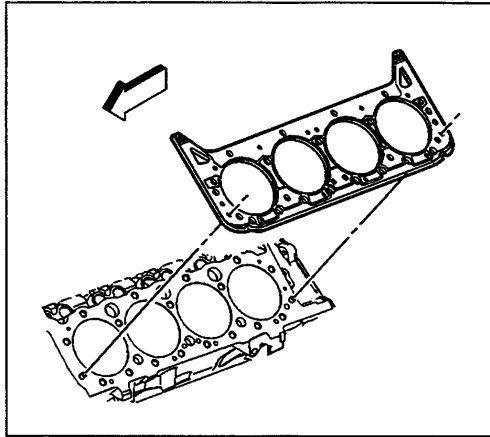
2. Remove the cylinder head bolts.



Notice: SIO-ID = 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

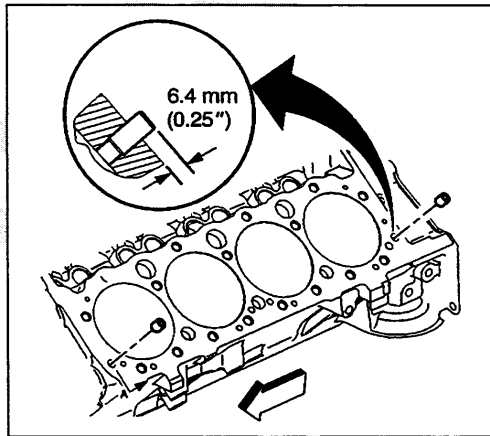
3. Remove the cylinder head.

4. Remove and discard the cylinder head gasket.



317233

5. Remove the dowel pin (cylinder head locator) (if required).

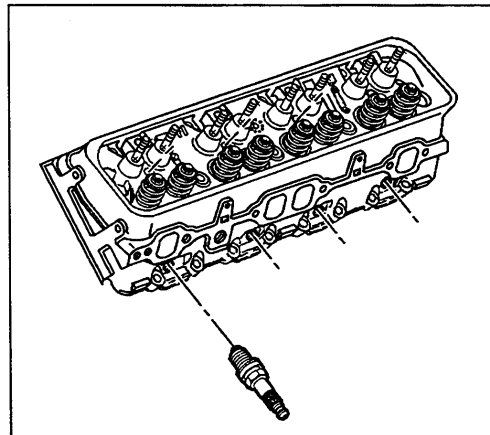


182846

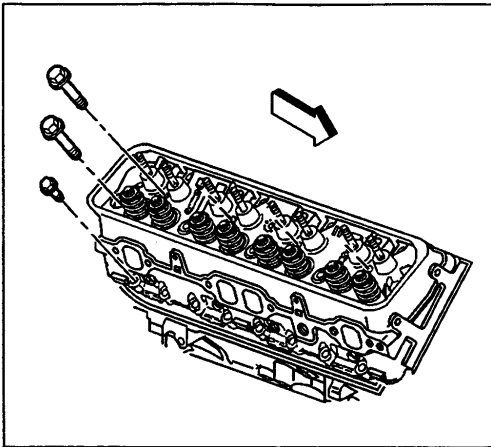
SIE-ID - 195376

Cylinder Head Removal (Right)

1. Remove and discard the spark plugs.

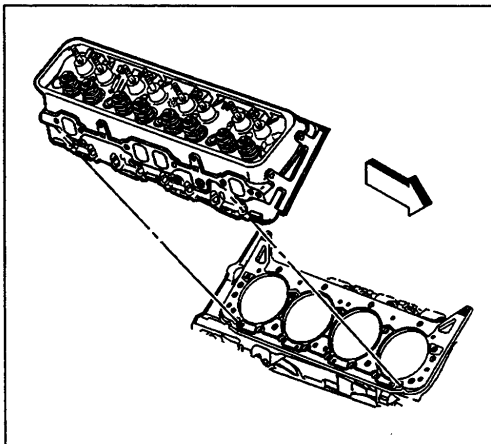


317307



317239

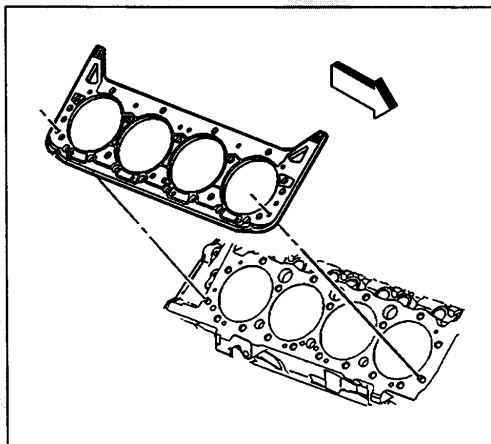
2. Remove the cylinder head bolts.



317246

Notice: S10-ID - 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

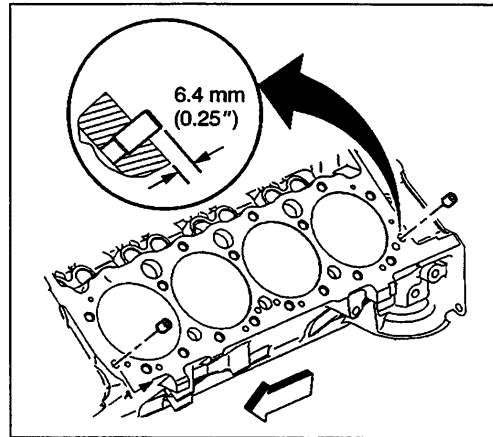
3. Remove the cylinder head.



317255

4. Remove and discard the cylinder head gasket.

5. Remove the dowel pin (cylinder head locator) (if required).



182846

SIE-ID = 24119

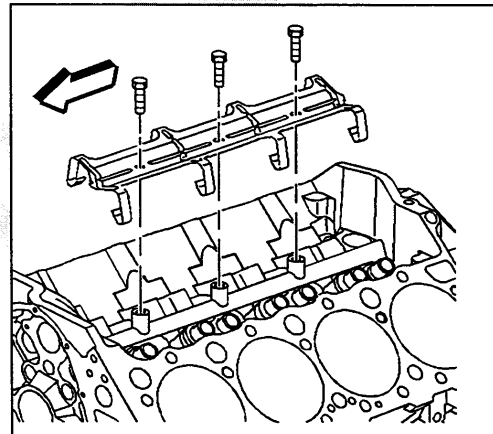
Valve Lifter Removal

SIO-ID = 14197

Tools Required

J 3049-A Valve Lifter Remover

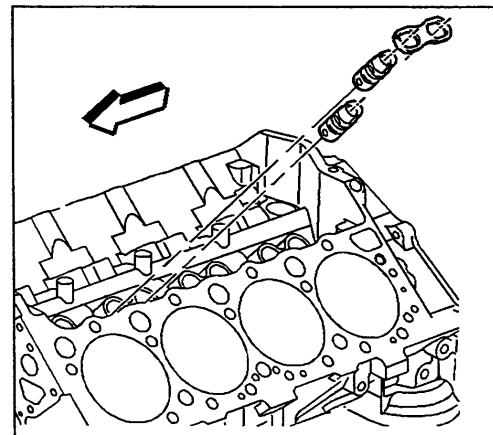
1. Remove the bolts and valve lifter guide retainer.



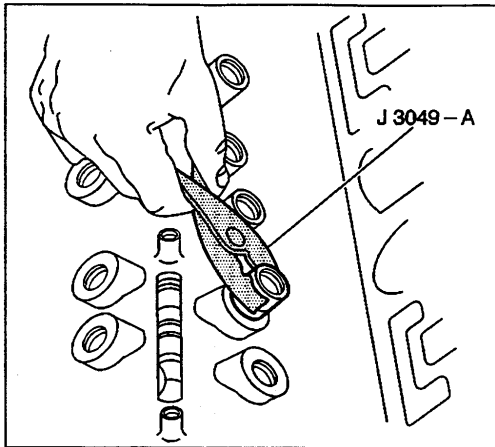
11508

Important: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifter.

2. Remove the valve lifter guides.
3. Place the components in a rack so that the components can be reinstalled to the original location.



11509



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Important: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits.

4. Use the J 3049-A in order to remove the stuck valve lifters.

SIE-ID = 66836

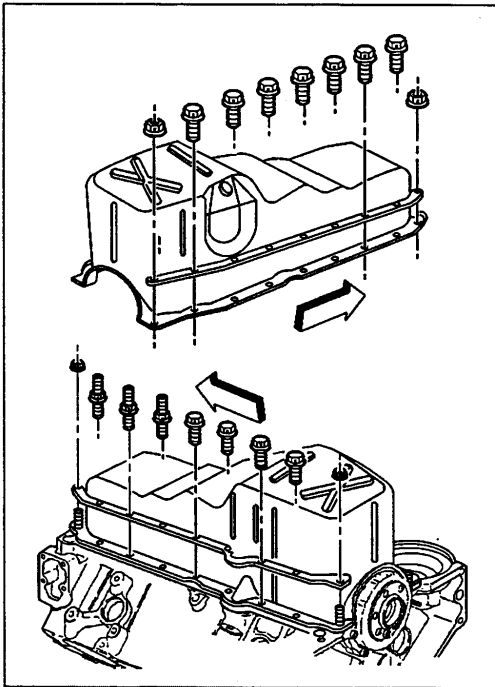
Oil Pan Removal

SIO-ID = 66938

1. Remove the oil pan bolts and nuts.
2. Remove the oil pan reinforcements.
3. Remove the oil pan.
4. Remove and discard the oil pan gasket.

Important: Note the location of the oil pan studs for assembly.

5. Remove the oil pan studs.



182851

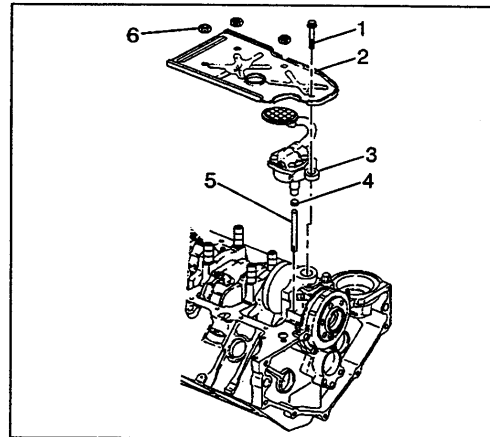
SIE-ID - 195387

Oil Pump, Pump Screen and Deflector Removal

1. Remove the nuts (6) and the crankshaft oil deflector (2).
2. Remove the oil pump bolt (1).
3. Remove the oil pump (3), the oil pump driveshaft (5), and the oil pump driveshaft retainer (4).
4. Separate the oil pump (3), the oil pump driveshaft (5), and the oil pump driveshaft retainer (4).

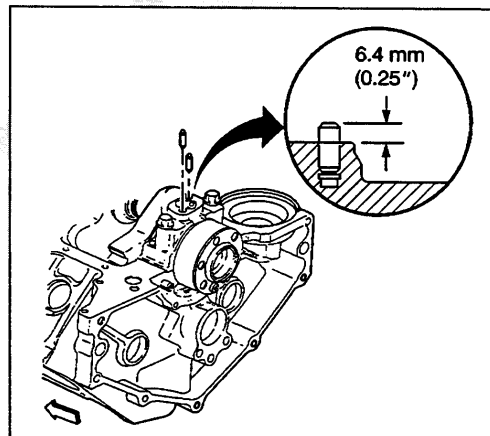
Important: Always install a NEW oil pump driveshaft retainer during assembly.

5. Discard the oil pump driveshaft retainer.



11438

6. Inspect the pins (oil pump locator) for damage, replace the pins if required.

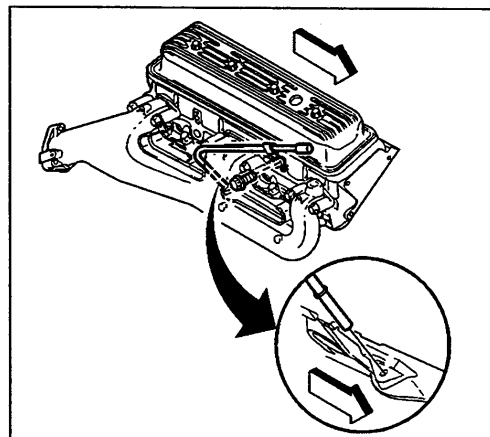


182852

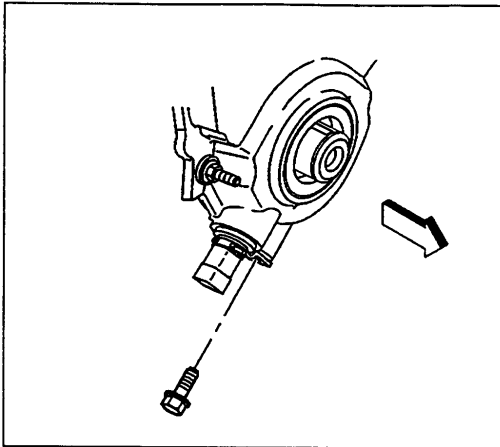
SIE-ID - 32348

Oil Level Indicator and Tube Removal

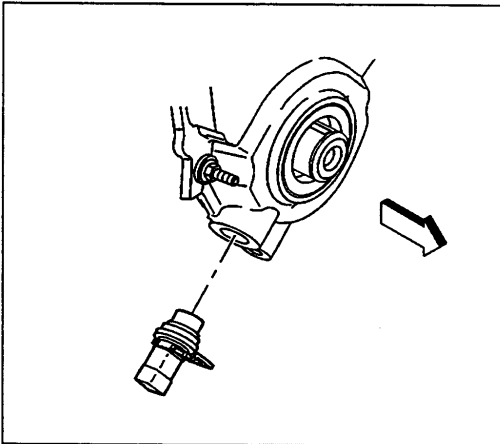
1. Remove the oil level indicator from the oil level indicator tube.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.



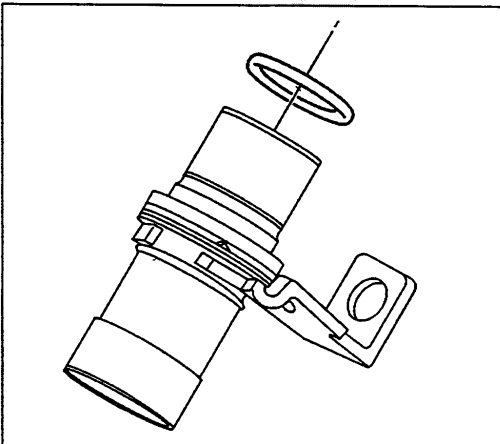
182831



10938



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387759

SIE-ID = 195381

Engine Front Cover Removal

1. Remove the crankshaft position sensor bolt.

2. Remove the crankshaft position sensor.

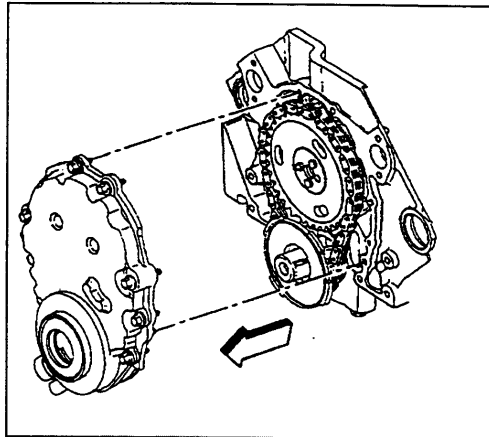
Important: Always install a NEW crankshaft position sensor seal (O-ring) during assembly.

3. Remove the crankshaft position sensor seal (O-ring).
4. Discard the crankshaft position sensor seal (O-ring).

Engine

Engine Mechanical - 5.0L, 5.7L 6-149

5. Remove the engine front cover bolts.
6. Remove the engine front cover and gasket.
Important: DO NOT reuse the composite engine front cover and gasket. Always install a NEW engine front cover.
7. Discard the engine front cover and gasket.



69010

SIE-ID = 66838

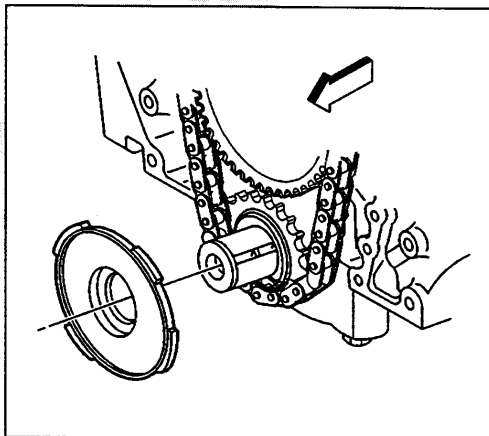
Timing Chain and Sprockets Removal

SIO-ID = 66890

Tools Required

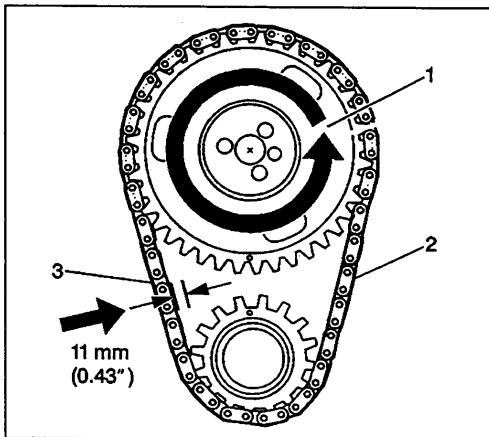
J 5825-A Crankshaft Gear Remover

1. Remove the crankshaft position sensor reluctor ring.

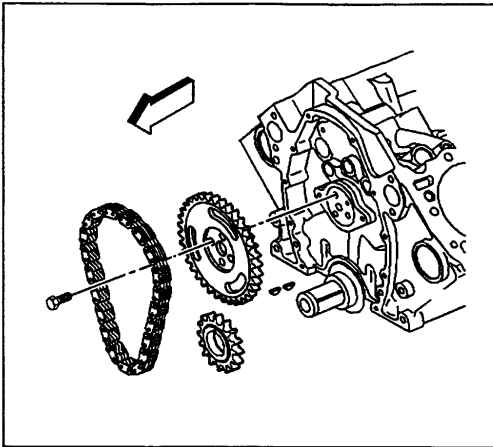


69450

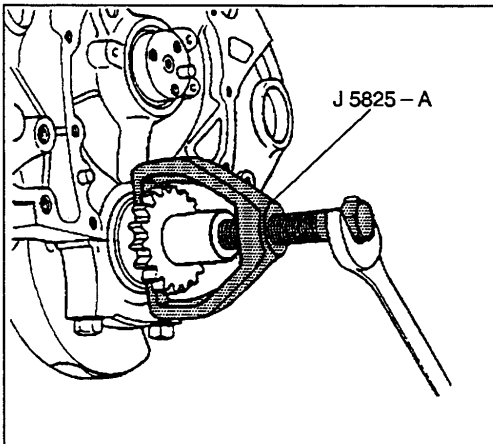
2. Check the camshaft timing chain free play.
If the camshaft timing chain can be moved in excess of 11 mm (0.43 in), replacement of the camshaft timing chain and the sprockets is recommended during assembly.
 - 2.1. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).
 - 2.2. Measure the free play on the slack side (3) of the camshaft timing chain.



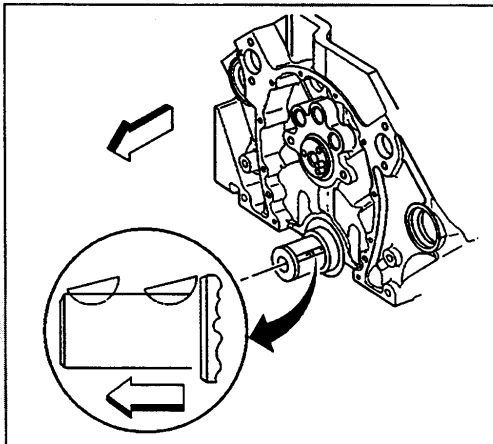
341357



65453



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3. Remove the camshaft sprocket bolts.
4. Remove the camshaft sprocket.
5. Remove the camshaft timing chain.

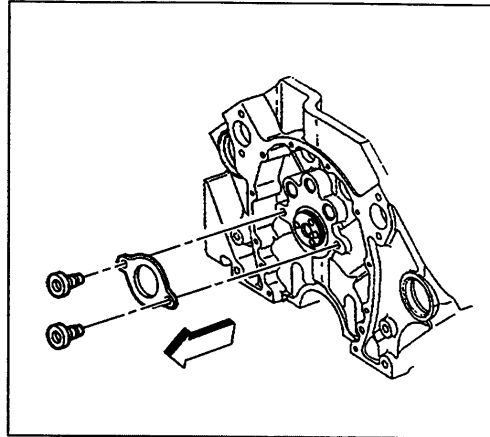
6. Remove the crankshaft sprocket using the *J 5825-A*.

7. Remove the woodruff keys (crankshaft balancer) (if required).

SIE-ID = 69031

Camshaft Removal

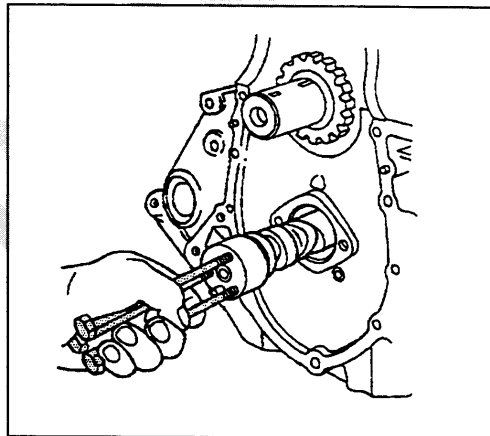
1. Remove the bolts and the camshaft retainer.



182836

Notice: SIO-ID = 13833 All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

2. Remove the engine camshaft.
 - 2.1. Install the three 5/16-18 x 4.0 inch bolts in the engine camshaft front bolt holes.
 - 2.2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
 - 2.3. Remove the bolts from the front of the engine camshaft.



69013

SIE-ID = 24200

Piston, Connecting Rod, and Bearing Removal

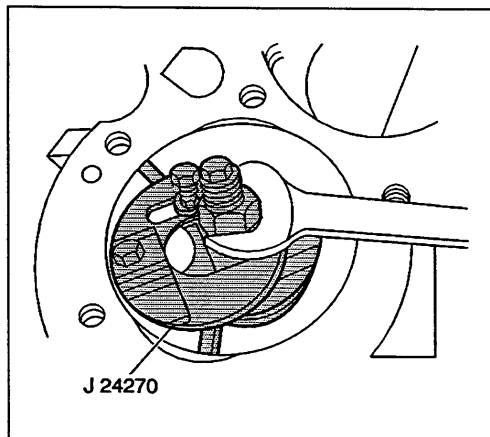
SIO-ID = 14210

Tools Required

- J 5239 Connecting Rod Bolt Guide Set
- J 24270 Cylinder Bore Ridge Reamer

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

1. Remove the ring ridge.
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on the top of the piston.
 - 1.3. Use the J 24270 in order to remove cylinder ring ridge.
 - 1.4. Turn the crankshaft so the piston is at the top of the stroke.
 - 1.5. Remove the cloth.

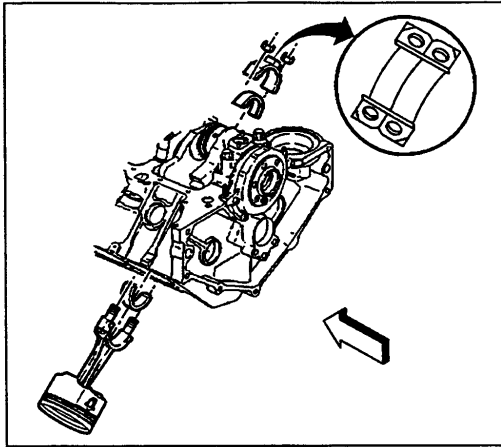


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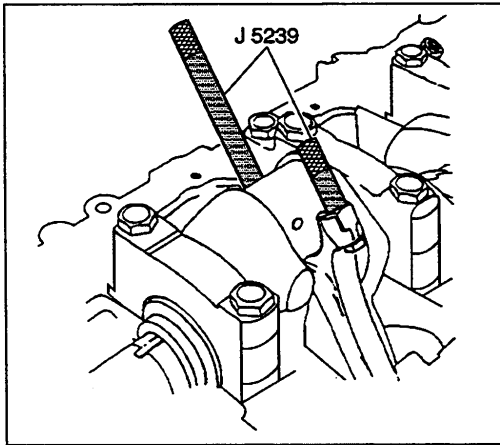
1.6. Remove the cutting debris.

Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps. Assemble the connecting rod caps to the matching connecting rods.

2. Remove the connecting rod nuts.
3. Remove the connecting rod cap.



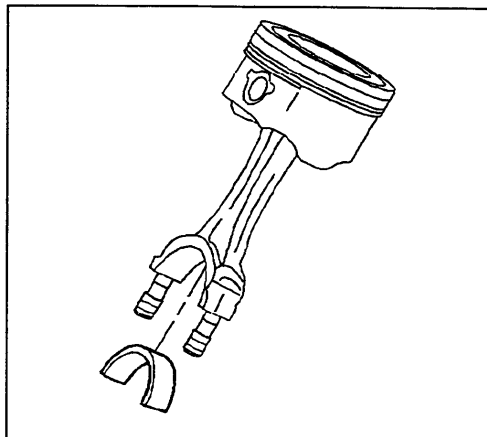
39124



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4. Use the J 5239 in order to protect the crankshaft journals and remove the connecting rod and the piston out of the top of the engine block.

5. Remove the connecting rod bearings.
 - Keep the connecting bearings with the original connecting rod and connecting rod cap.
 - Wipe the oil from the connecting bearings.
 - Wipe the oil from the crankpins.



5157

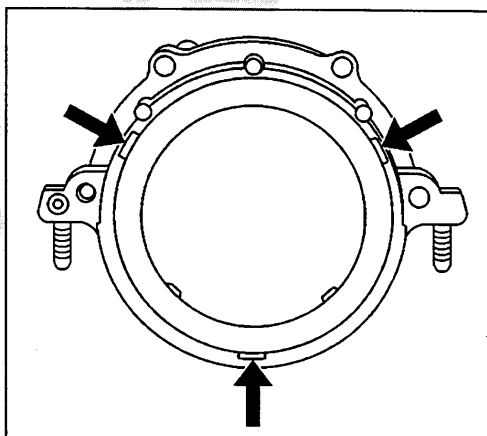
SIE-ID = 24222

Crankshaft Rear Oil Seal and Housing Removal

SIO-ID = 14231

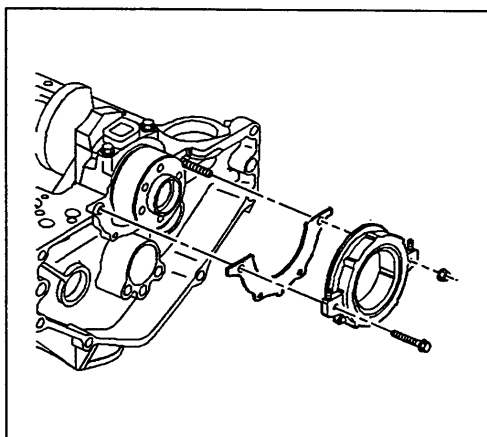
1. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.
2. Discard the crankshaft rear oil seal.

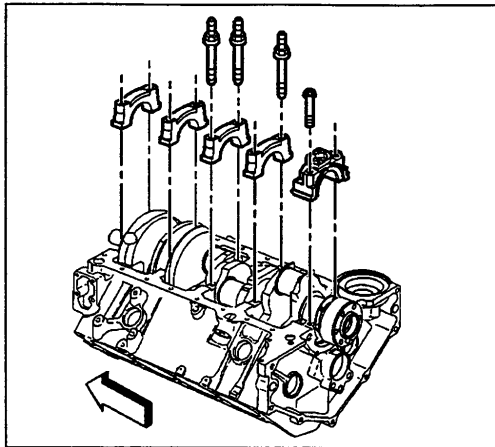


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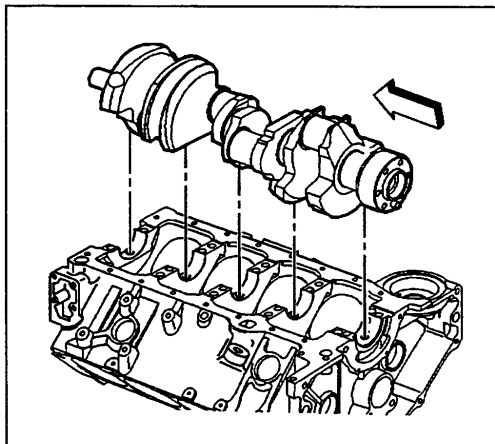
3. Remove the crankshaft rear oil seal housing nut and bolts.
4. Remove the crankshaft rear oil seal housing.
5. Remove the crankshaft rear oil seal housing gasket.
6. Discard the crankshaft rear oil seal housing gasket.
7. Remove the rear oil seal housing retainer stud from the engine block.



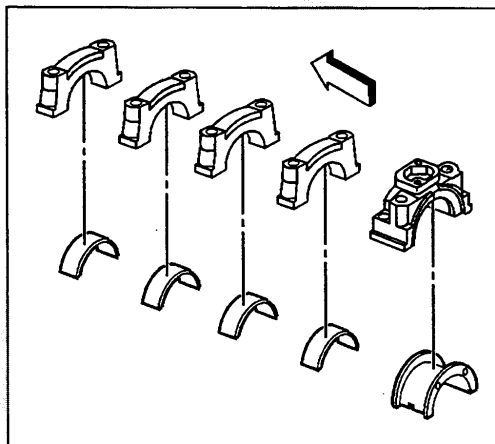
11479



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317351



317295

SIE-ID = 69426

Crankshaft and Bearings Removal

1. Mark or identify the crankshaft bearing cap locations and positions for assembly.
2. Remove the crankshaft bearing cap bolts and studs.
3. Remove the crankshaft bearing caps.

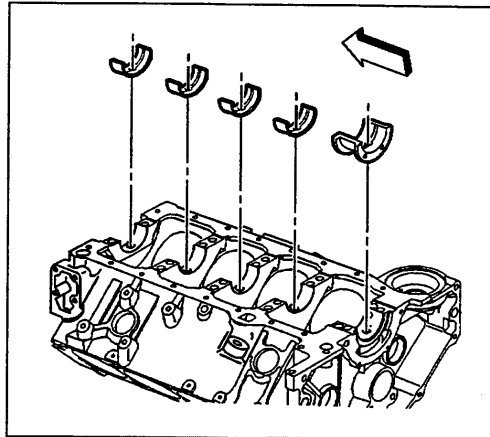
4. Remove the crankshaft.

5. Remove the crankshaft bearings from the crankshaft bearing caps.

Engine

Engine Mechanical - 5.0L, 5.7L 6-155

6. Remove the crankshaft bearings from the engine block.

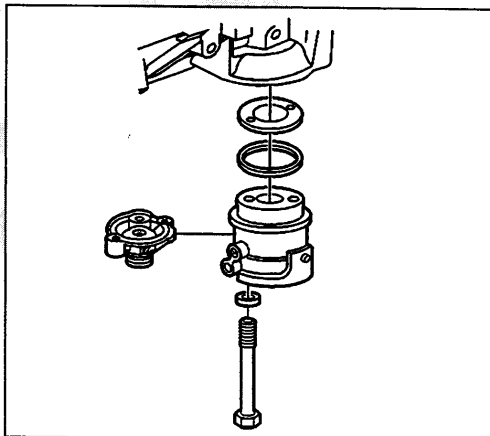


317292

SIE-ID = 69505

Oil Filter Adapter and Valve Assembly Removal

1. Remove the oil filter adapter bolts and washers (if applicable).
2. Remove the oil filter adapter.
3. Remove the oil filter adapter seal (O-ring), and the oil filter adapter gasket (if applicable).
4. Discard the oil filter adapter seal (O-ring) and the oil filter adapter gasket (if applicable).



39122

SIE-ID = 348910

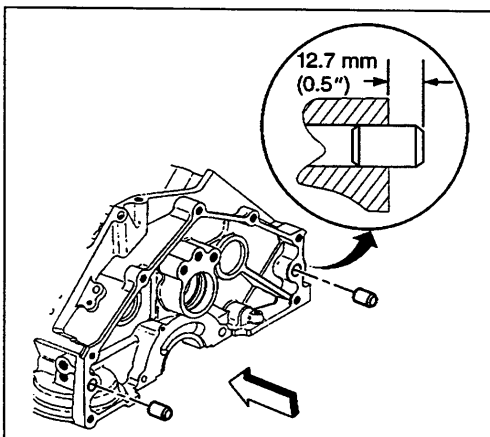
Engine Block Plug Removal

Tools Required

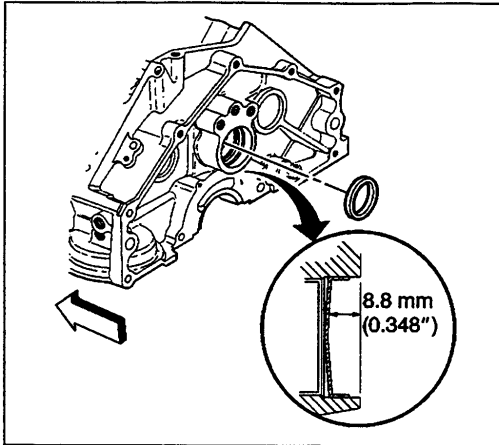
J 41712 Oil Pressure Switch Socket

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Remove the transmission locator pins (if required).

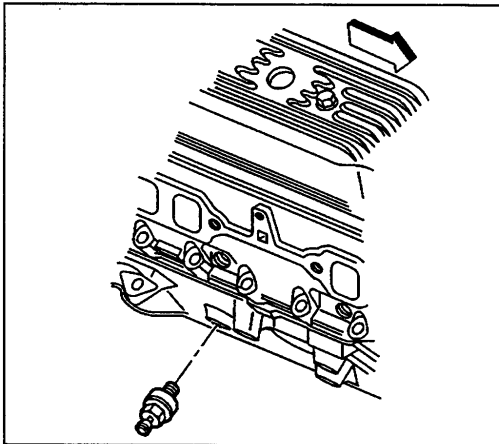


182655



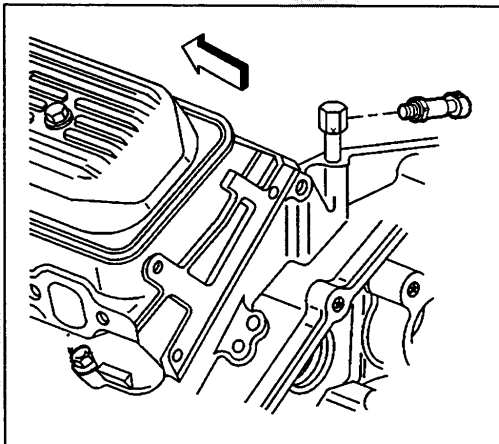
182854

2. Remove the expansion cup plug (camshaft rear bearing hole).



182837

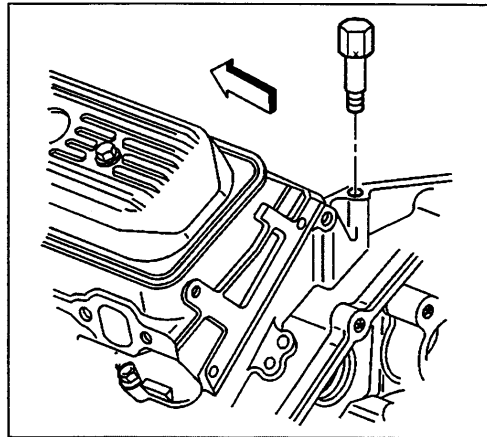
3. Remove the knock sensor.



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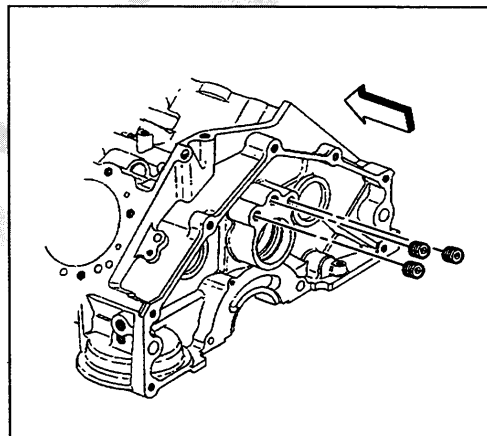
4. Remove the engine oil pressure gauge sensor using the J 41712.

5. Remove the engine oil pressure sensor gauge sensor fitting.



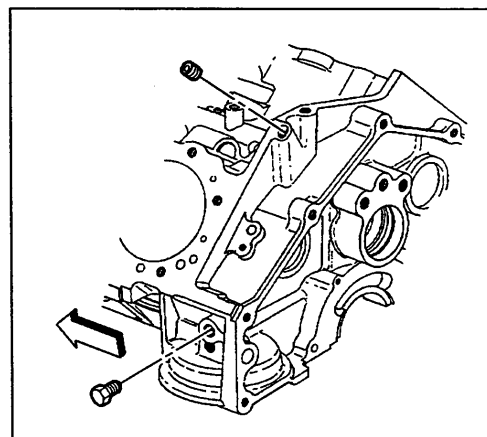
333652

6. Remove the square socket plugs (engine block oil gallery) from the rear of the engine block.

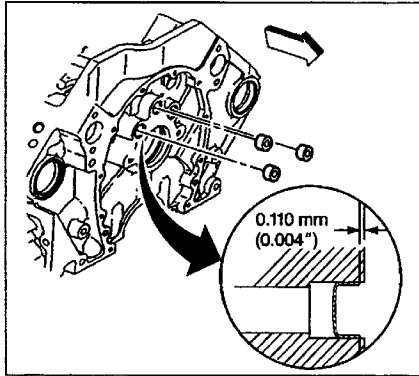


69847

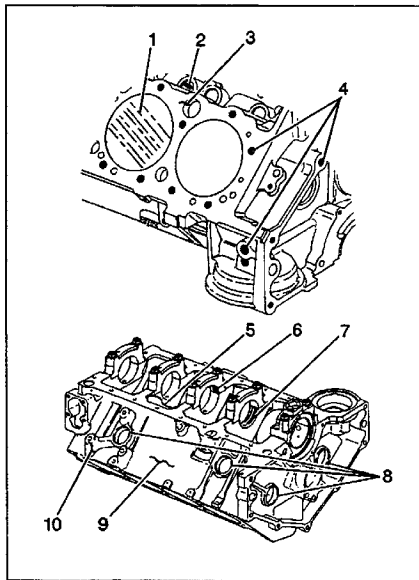
7. Remove the left side rear and left rear top engine block oil gallery plugs.



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8. Remove the engine block oil gallery plugs from the front of the engine block.

Insert a rod into the rear oil gallery holes in order to drive out the engine block oil gallery plugs.

SIE-ID - 66842

Engine Block Clean and Inspect

SIO-ID - 67829

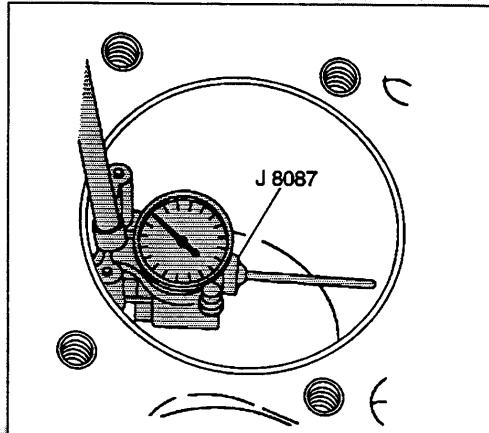
Tools Required

J 8087 Cylinder Bore Gauge

1. Clean all the remaining sealing or gasket material from the sealing surfaces.
2. Boil the engine block in caustic solution.
3. Flush the engine block with clean water or steam.
4. Clean the cylinder bores.
5. Clean the oil galleries and the oil passages.
6. Clean the scale and the deposits from the coolant passages.
7. After cleaning the engine block, spray or wipe the cylinder bores and the machined surfaces with clean engine oil GM P/N 12345610 or equivalent.
8. Inspect the following areas:
 - Cylinder bores (1) for scratches or gouging
 - Valve lifter bores (2) for excessive scoring or wear
 - Coolant jackets (3) for cracks
 - Threaded holes (4) for damage
 - Crankshaft bearing webs (5) for cracks
 - Crankshaft bearing caps (6) and the crankshaft bearing bores (7) for damage
 - The crankshaft bearing bores should be round and uniform when measuring the inside diameter (ID).
 - The surface where the crankshaft bearings contact the crankshaft bearing bore should be smooth.
 - If a crankshaft bearing cap is damaged and requires replacement, replace the crankshaft bearing cap first. Then rebore the engine block crankshaft bearing bores

and check for the proper alignment.
Finally, check the crankshaft bearings for the proper clearances.

- Expansion cup plug bores (8) for damage
 - Engine block (9) for cracks or damage
 - Engine mount bosses (10) for damage
9. Measure the cylinder bores for taper and out-of-round.
- 9.1. Depress the plunger on the *J 8087* 7 mm (0.275 in) or until the *J 8087* enters the cylinder bore.
 - 9.2. Center the *J 8087* in the cylinder bore and turn the indicator dial to zero.
 - 9.3. Move the *J 8087* up and down the cylinder bore to determine the taper. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
 - 9.4. Turn the *J 8087* to different points around the cylinder bore to determine the out-of-round condition. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.



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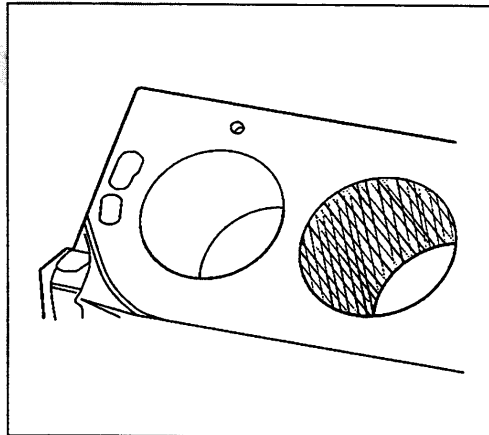
SIE-ID = 69045

Cylinder Boring and Honing

Cylinder Honing

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
 - Use only clean sharp stones of the proper grade for the amount of material to be removed.
 - Dull, dirty stones cut unevenly and generate excessive heat.
 - DO NOT hone to a final grade with a coarse or medium-grade stone.
 - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
 - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45–65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
 - Repeatedly check the cylinder bore fit with the selected piston.
 - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the



186747

cylinder bore.

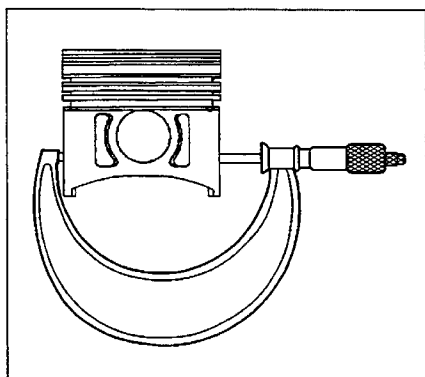
Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

- The finish marks should be clean but not sharp.
 - The finish marks should be free from imbedded particles or torn or folded metal.
4. By measuring the selected piston at the sizing point and then by adding the average of the clearance specification, the final cylinder bore honing dimension required can be determined.
 5. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
 6. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
 - 6.1. Scrub the cylinder bores with a stiff bristle brush.
 - 6.2. Rinse the cylinder bores thoroughly with clean hot water.
 - 6.3. Dry the cylinder bores with a clean rag.
 - 6.4. Do not allow any abrasive material to remain in the cylinder bores.
 - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
 - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
 7. Perform final measurements of the piston and the cylinder bore.
 8. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
 9. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Boring Procedure

Caution: *SIO-10 - 5011 Wear safety glasses in order to avoid eye damage.*

1. Before starting the honing or reboring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. File the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding use of the boring equipment.
4. When reboring the cylinders, make sure all the crankshaft bearing caps are installed in the original position and direction.
5. Tighten the crankshaft bearing caps to the proper torque specifications in order to avoid distortion of the cylinder bores in the final assembly.
6. When making the final cut with the boring bar,



188016

leave 0.03 mm (0.001 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between the pistons, the piston rings, and the cylinder bores).

SIE-ID = 69074

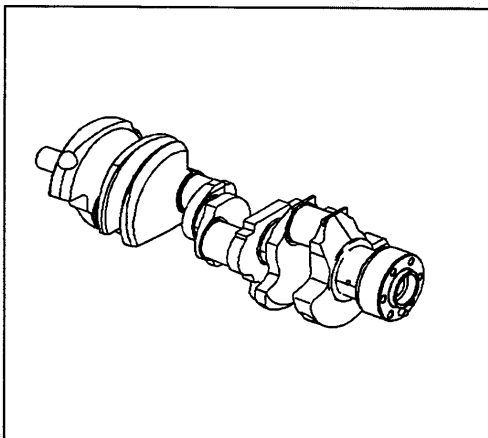
Crankshaft and Bearings Clean and Inspect

Tools Required

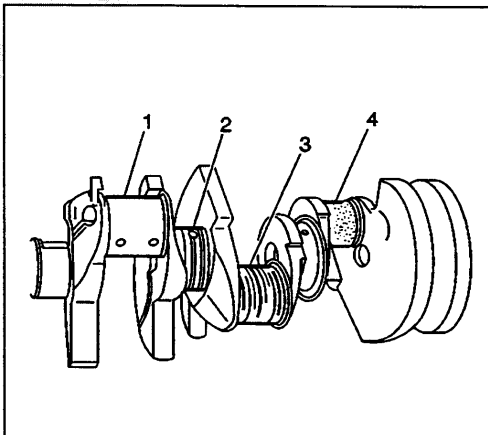
- J 7872 Magnetic Base Dial Indicator
- J 36660 Electronic Torque Angle Meter

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

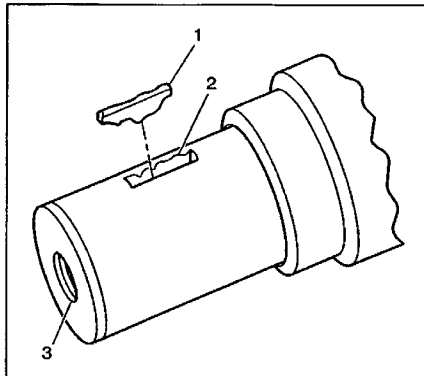
1. Clean the crankshaft in cleaning solvent. Remove all sludge or restrictions from the oil passages.
2. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a soft cloth, do not scratch the crankshaft bearing surfaces.
3. Dry the crankshaft and crankshaft bearings with compressed air.
4. Inspect the crankshaft for the following:
 - Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
 - Deep grooves (2)
 - Scratches or uneven wear (3)
 - Pitted surfaces (4)
 - Wear of damage to the thrust journal surfaces
 - Scoring or damage to the front or rear seal surface
 - Restrictions to the oil passages
 - A loose or damaged rear oil gallery plug
 - Damage to the threaded bolt holes



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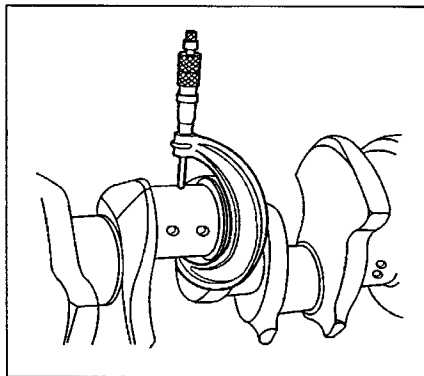


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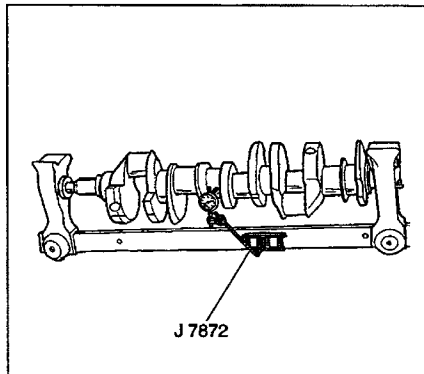
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5. Inspect the woodruff keys (crankshaft balancer) (1), the keyway (2), and the threaded hole (3) for damage.



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6. Measure the crankpins for out-of-round and taper.



35210

7. Using wooden V-blocks, support the crankshaft on the front and rear journals.
8. Use the J 7872 in order to measure crankshaft journal runout.
- The crankshaft runout should not exceed 0.038 mm (0.0015 in).

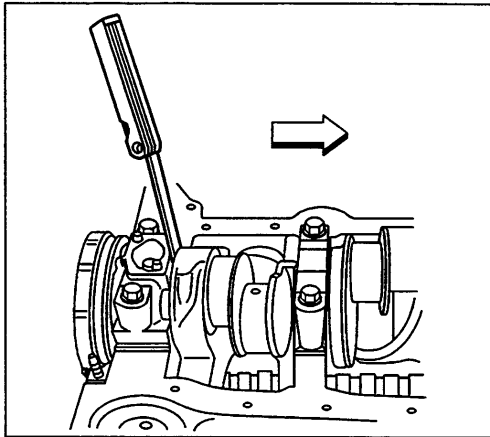
9. Measure the crankshaft end play.

Important: In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings, the crankshaft bearing caps, and the fasteners must be installed into the engine block and the bolts and studs tightened to specifications.

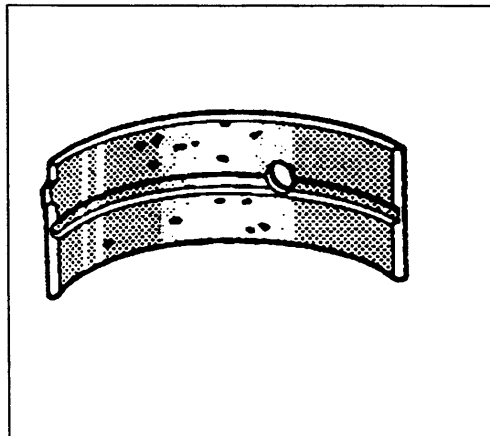
- 9.1. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
- 9.2. With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the crankshaft bearing surface and then measure the clearance. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
- 9.3. If the correct end play cannot be obtained, verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
- 9.4. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one crankshaft bearing cap at a time, until the tight crankshaft bearing is located.

Burrs on the crankshaft bearing cap, foreign matter between the crankshaft bearing and the engine block or the crankshaft bearing cap, or a faulty crankshaft bearing could cause a lack of clearance at the crankshaft bearing.

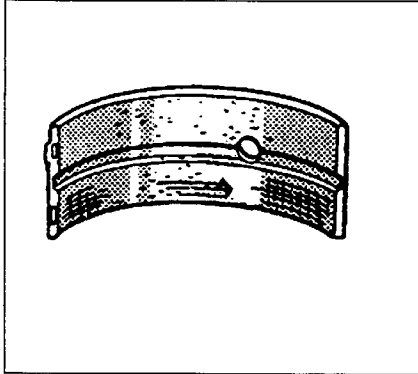
10. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.



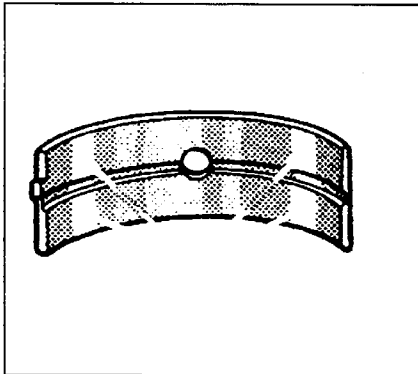
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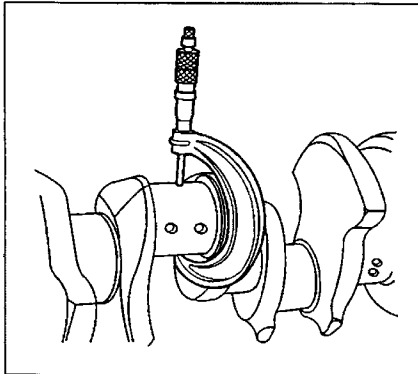
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11. Inspect the crankshaft bearings for excessive scoring or discoloration.
12. Inspect the crankshaft bearings for dirt or debris imbedded into the crankshaft bearing material.

13. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the crankshaft bearings.

If the lower half of the crankshaft bearing is worn or damaged, both the upper and lower halves of the crankshaft bearing should be replaced.

Generally, if the lower half of the crankshaft bearing is suitable for use, the upper half of the crankshaft bearing should also be suitable for use.

Bearing Clearance Measuring Procedures

The crankshaft bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, then new upper and lower crankshaft bearings will be required. The service crankshaft bearings are available in the standard size and an undersize.

The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of an undersize crankshaft bearing.

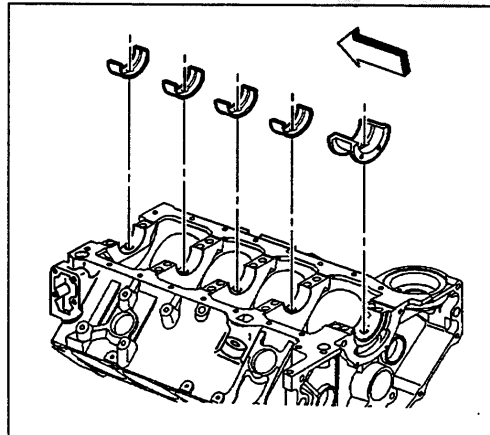
In order to determine the correct replacement crankshaft bearing size, the crankshaft bearing clearance must be measured accurately. Either the micrometer or plastic gauge method may be used; however, the micrometer method gives more reliable results and is preferred.

Micrometer Method for Crankshaft Bearings

1. Measure the crankshaft journal diameter with a

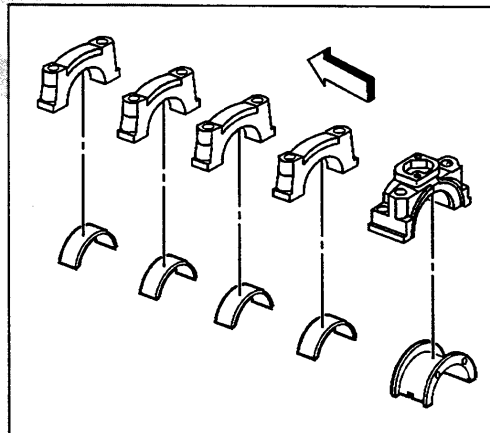
micrometer in several places, approximately 90 degrees apart, and then average the measurements.

2. Determine the taper and the out-of-round of the crankshaft journal. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
3. Install the crankshaft bearings into the engine block.

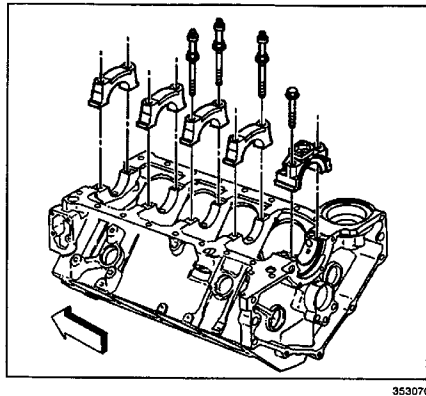


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4. Install the crankshaft bearings into the crankshaft bearing caps.



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Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts and studs.

Tighten

- 6.1. Tighten the crankshaft bearing cap bolts and studs on the first pass to 20 N.m (15 lb ft).
- 6.2. Tighten the crankshaft bearing cap bolts and studs (two bolt caps) on the final pass to 73 degrees using the *J 36660*.
- 6.3. Tighten the outboard crankshaft bearing cap bolts and studs (four bolt cap) on the final pass to 43 degrees using the *J 36660*.
- 6.4. Tighten the inboard crankshaft bearing cap bolts and studs (four bolt caps) on the final pass to 73 degrees using the *J 36660*.
7. Measure the crankshaft bearing inside diameter (ID) at the top and bottom using an inside micrometer.
8. In order to determine the crankshaft bearing clearance, subtract the journal diameter from the crankshaft bearing ID.
9. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
10. If the crankshaft bearing clearances exceeds specifications, install the new crankshaft bearings as follows:
 - 10.1. Measure the crankshaft bearing inside diameter (ID) using an inside micrometer.
 - 10.2. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.

Replace or repair the crankshaft if the proper clearances cannot be obtained.

Micrometer Method for Connecting Rod Bearings

Notice: *SIO-ID - 5016* Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

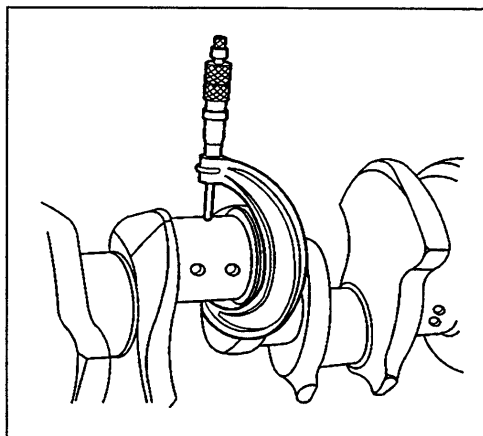
1. Measure the crankpin diameter with a micrometer in several places, approximately 90 degrees apart, and then average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
3. Install the connecting rod bearings into the connecting rod cap and the connecting rod.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

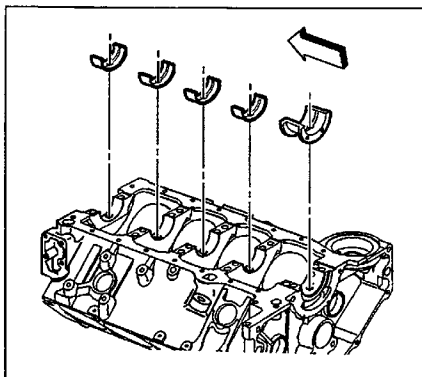
4. Install the connecting rod caps and the nuts.

Tighten

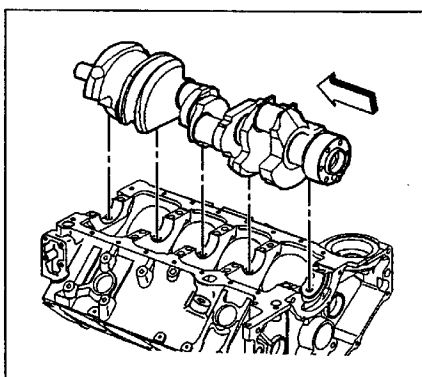
- 4.1. Tighten the connecting rod nuts in the first pass, evenly to 27 N·m (20 lb ft).
 - 4.2. Tighten the connecting rod nuts in the final pass an additional 55 degrees using the *J 36660*.
5. Measure the connecting rod bearing inside diameter (ID) at the top and bottom using an inside micrometer.
 6. Compare the connecting rod bearing clearance specifications. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
 7. If the connecting rod bearing clearance is within specifications, the connecting rod bearing is satisfactory.
 - If the clearance is not within specifications, replace the connecting rod bearings.
 - Always replace both the upper and the lower connecting rod bearings as an assembly.
 8. A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it will be necessary to replace or repair the crankshaft.



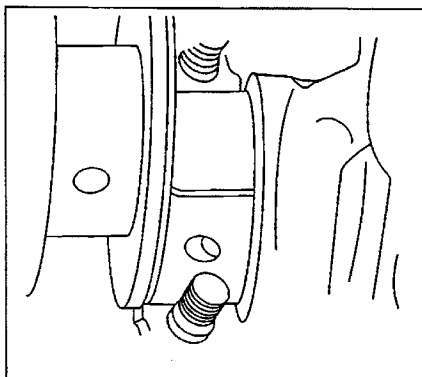
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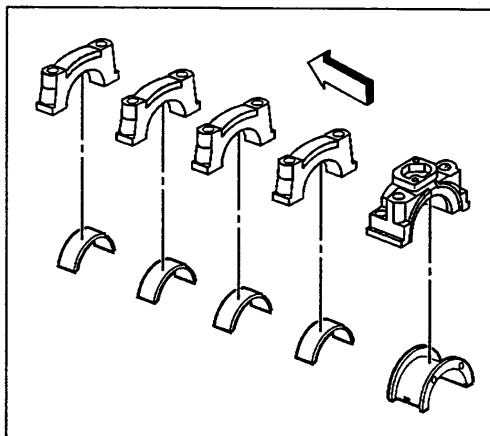


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Plastic Gauge Method for Main or Connecting Rod Bearings

1. Install the crankshaft bearings into the engine block.
2. Install the crankshaft.
3. Install the gauging plastic the full width of the journal.

4. Install the crankshaft bearings into the crankshaft bearing caps



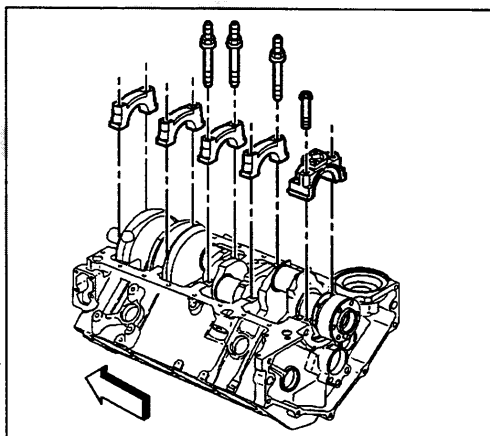
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Notice: Refer to *Fastener Notice* in Cautions and Notices.

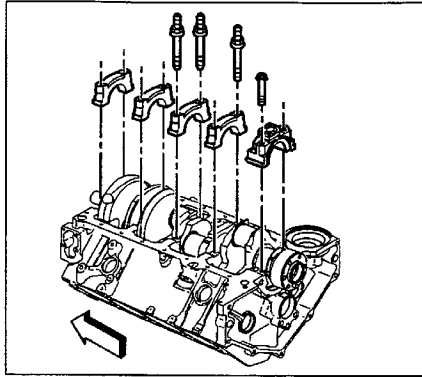
5. Install the crankshaft bearing caps in the original positions and the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts and studs.

Tighten

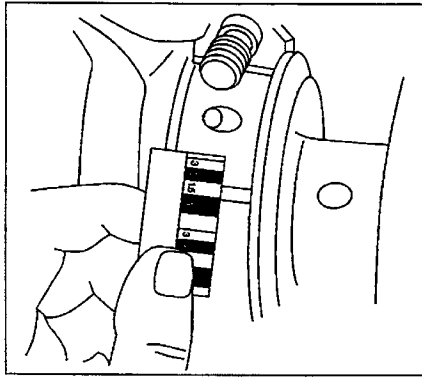
- 6.1. Tighten the crankshaft bearing cap bolts and studs on the first pass to 20 N.m (15 lb ft).
- 6.2. Tighten the crankshaft bearing cap bolts and studs (two bolt caps) on the final pass to 73 degrees using the *J 36660*.
- 6.3. Tighten the outboard bearing cap bolts and studs (four bolt cap) on the final pass to 43 degrees using the *J 36660*.
- 6.4. Tighten the inboard bearing cap bolts and studs (four bolt caps) on the final pass to 73 degrees using the *J 36660*.



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7. Remove the crankshaft bearing cap bolts and studs.

8. Remove the crankshaft bearing caps. The gauging plastic may adhere to either the crankshaft bearing journal or the crankshaft bearing surface.

9. Without removing the gauging plastic, measure the compressed width at the widest point using the graduated scale on the edge of the gauging plastic envelope.

If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft bearing journal.

- Normally the crankshaft bearing journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round 0.0254 mm (0.001 in) (maximum) crankshaft bearing journal, be sure to fit to the maximum diameter of the crankshaft bearing journal. If the crankshaft bearing is fitted to the minimum diameter and the crankshaft bearing journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft bearing journal will result in rapid crankshaft bearing failure.
- If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory. If the clearance is not within specifications, replace the crankshaft bearing. Always replace both the upper and lower crankshaft bearings as a unit.
- A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.

Notice: S10-10 - 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

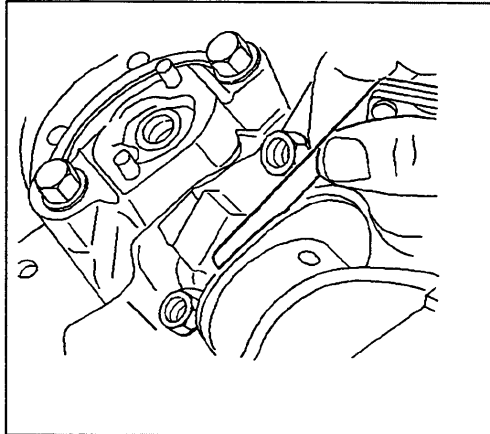
10. Remove the flattened gauging plastic.

11. Measure the remaining crankshaft and

connecting rod bearing journals.

Connecting Rod Side Clearance Measuring Procedure

1. Insert a feeler gauge between the connecting rod caps and measure the connecting rod side clearance. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
2. The connecting rod side clearances may also be measured with a dial indicator set.



5163

SIE-ID - 194518

Crankshaft Balancer Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the crankshaft balancer in cleaning solvent.
2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
 - Worn or damaged bolt hole threads (1)
 - Worn, chunking, or deteriorated rubber (2) between the hub and pulley
 - Loose or improperly installed balance weights (3)

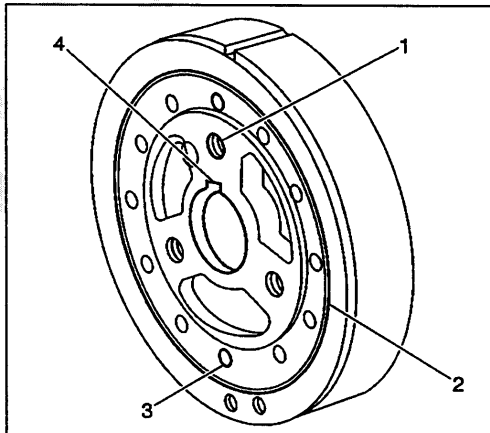
A properly installed balance weight should be installed until flush or below flush with the face of the crankshaft balancer.

- Worn or damaged keyway (4)

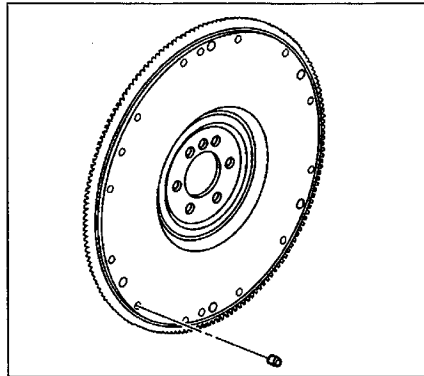
Important: A crankshaft front oil sealing surface with excessive scoring, grooves, rust, or other damage must be replaced.

- Worn, grooved, or damaged crankshaft front oil sealing surface

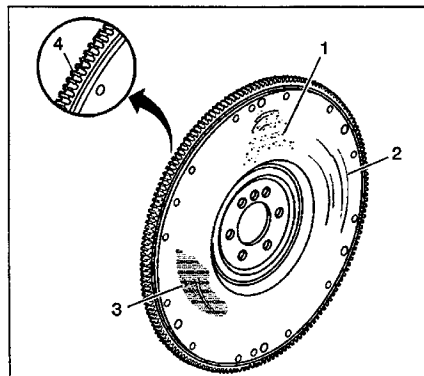
Minor imperfections on the crankshaft balancer crankshaft front oil seal surface may be removed with a polishing compound or fine grade emery cloth.



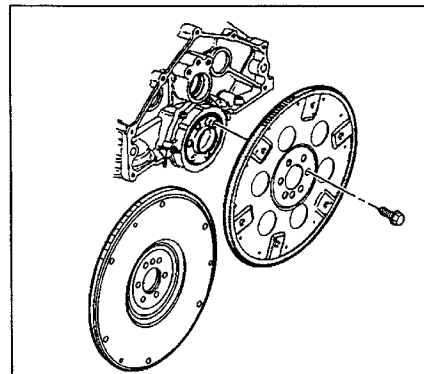
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SIE-ID = 185065

Engine Flywheel Clean and Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the engine flywheel in cleaning solvent.
2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel (manual transmission) for loose or improperly installed flywheel weights (if applicable).

A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

4. Inspect the engine flywheel (manual transmission) for the following:

- Pitted surface (1)
- Scoring or grooves (2)
- Rust or other surface damage
- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the engine flywheel and the ring gear should be positioned completely flat against the flange of the engine flywheel.

Important: Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel. Install a NEW engine flywheel if any cracks are found.

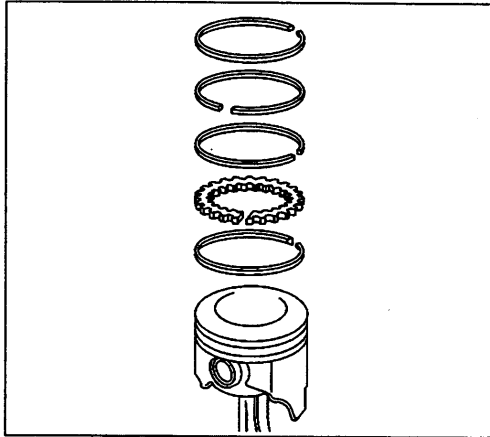
5. Inspect the engine flywheel (automatic transmission) for the following:

- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations.
- Welded areas that retain the ring gear onto the engine flywheel for cracking.

SIE-ID - 195087

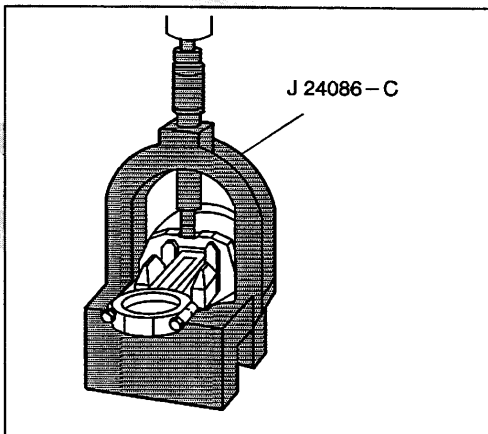
Piston and Connecting Rod Disassemble**Tools Required***J 24086-C* Piston Pin Remover/Installer**Caution:** *SIO-ID - 5011* **Wear safety glasses in order to avoid eye damage.**

1. Remove the piston rings from the pistons.



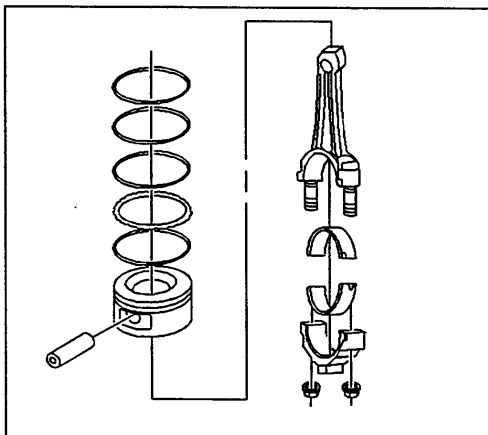
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2. Press the piston pin from the connecting rod using the *J 24086-C*.
The piston pin has an interference fit into the connecting rod, and is full floating in the piston.

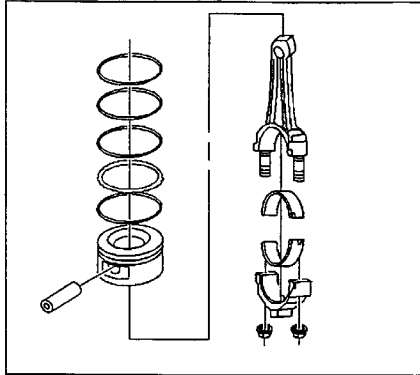


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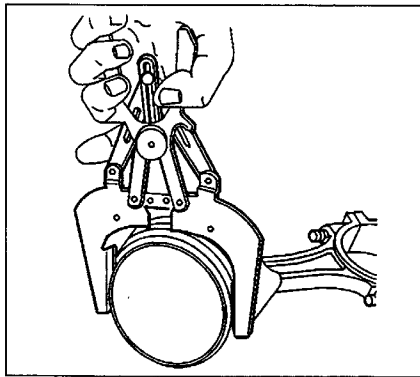
3. Mark, separate, and organize the parts for assembly.



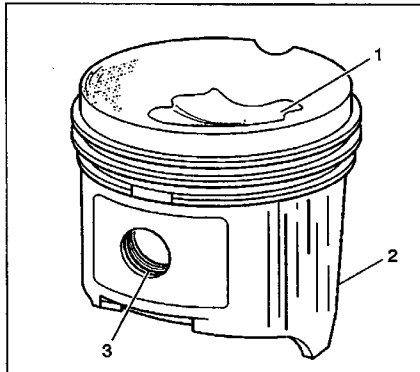
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34671



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SIE-ID = 39133

Piston, Connecting Rod and Bearings Clean/Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

Important: Measurement of all components should be taken with the components at room temperature. Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston and connecting rod in cleaning solvent.

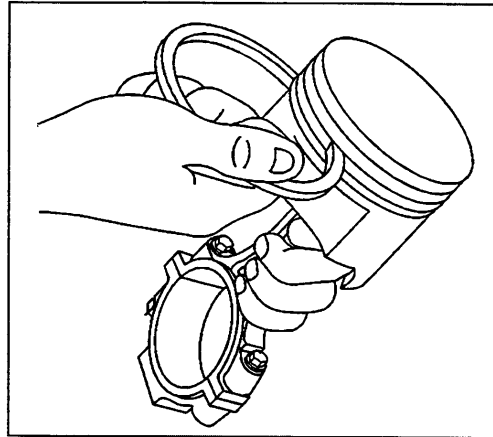
Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

2. Dry the components with compressed air.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.

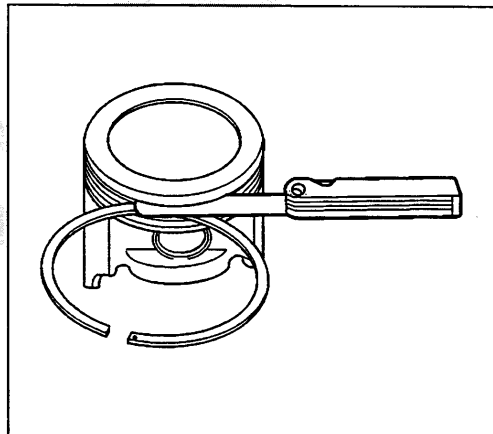
4. Clean the piston oil lubrication holes and slots.
5. Inspect the piston for the following:
 - Eroded areas (1) on the top of the piston
 - Scuffed or damaged skirt (2)
 - Damage to the piston pin bore (3)
 - Cracks in the piston ring lands, the piston skirt, or the piston pin bosses
 - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind.
6. Inspect the piston pin for scoring, wear or other damage.

7. Measure the piston ring-to-piston ring groove side clearance.
 - 7.1. Insert the edge of the piston ring into the piston ring groove.
 - 7.2. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, then replace the piston ring.



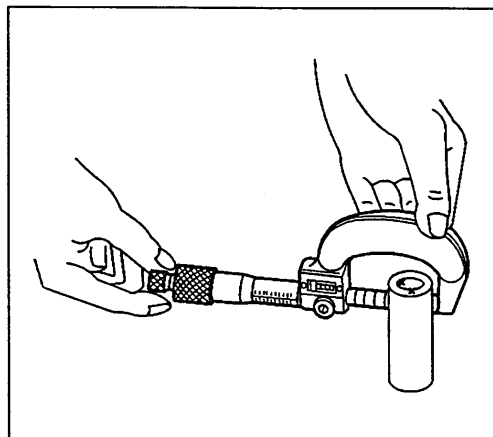
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8. Measure the piston ring side clearance with a feeler gauge.
 - If the piston ring side clearance is too small, try another piston ring set.
 - If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
9. To determine the proper piston ring side clearance, refer to *Engine Mechanical Specifications (L31 (VIN R))*.

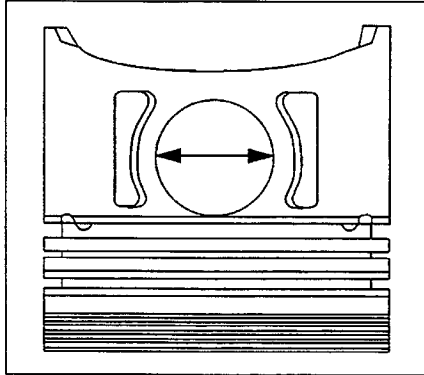


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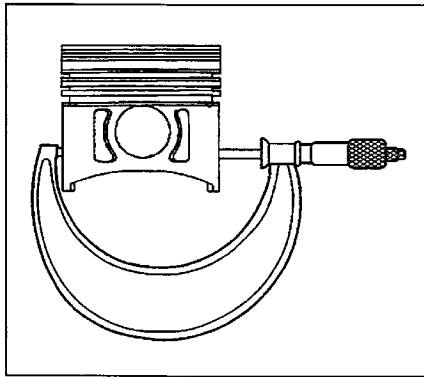
10. To determine piston pin-to-bore clearance use a micrometer and measure the piston pin.



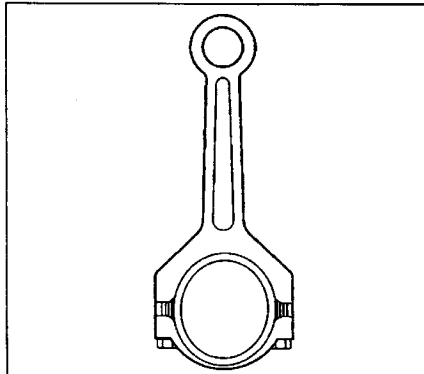
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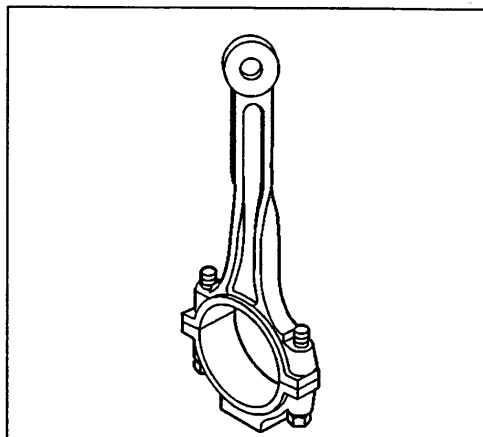
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11. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
12. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
13. Measure the piston for out-of-round.
 - 13.1. With a micrometer at a right angle to the piston, measure the piston at 11 mm (0.433 in) from the bottom of the skirt.
 - 13.2. Measure the piston at three different points 120 degrees apart and compare the readings, refer to *Engine Mechanical Specifications (L31 (VIN R))*.
If the clearance is not within specifications, then replace the piston and piston pin as an assembly.
14. Inspect the connecting rod for an out-of-round bearing bore.

15. Inspect the connecting rod for twisting.
16. Inspect the connecting rod for damage to the connecting rod bolt threads.

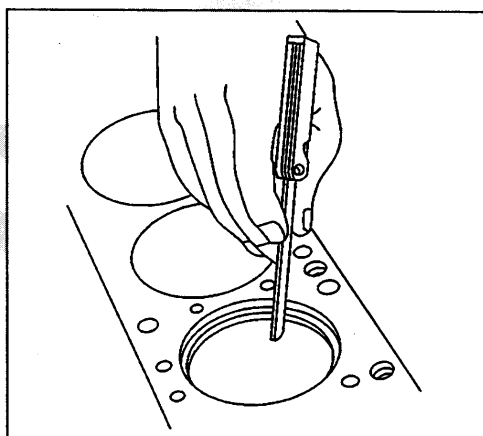


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17. Measure the piston compression ring end gap.

Important: Fit each piston compression ring to the cylinder in which it will be used.

- 17.1. Place the piston compression ring into the cylinder bore.
- 17.2. Push the piston compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the piston ring travel. The piston ring must be square to the cylinder wall.
- 17.3. Use a feeler gage in order to measure the piston ring end gap. Select another size piston ring set if the piston ring end gap exceeds specifications.



4968

SIE-ID - 197522

Piston Selection

Tools Required

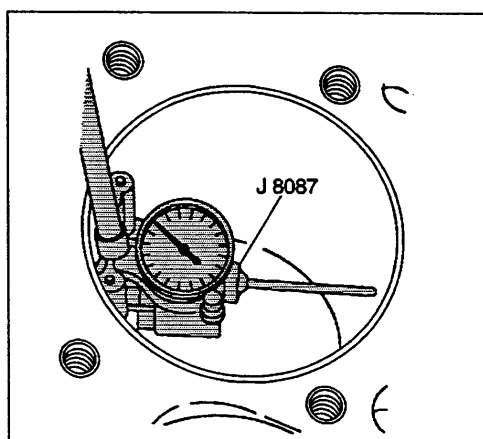
J 8087 Cylinder Bore Gauge

Important: Measurements of all components should be taken with the components at normal room temperature.

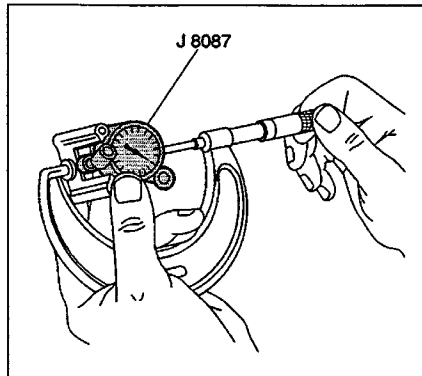
For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, the piston and pin set are within specifications.

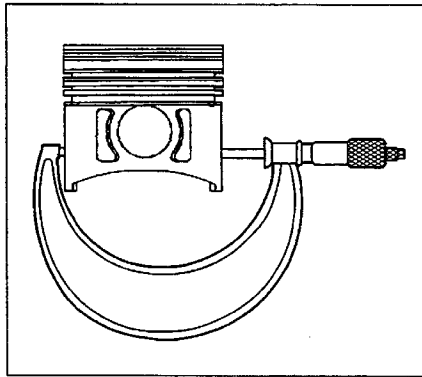
1. Inspect the engine block cylinder bore. Refer to *Engine Block Clean and Inspect*.
2. Inspect the piston and piston pin. Refer to *Piston, Connecting Rod and Bearings Clean/Inspect*.



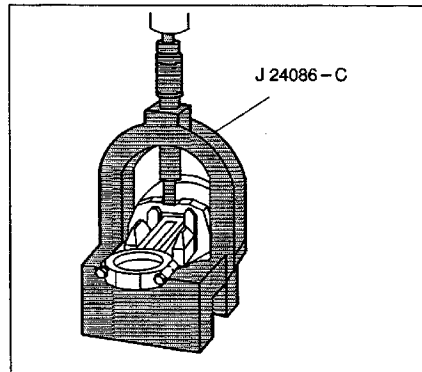
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3. Measure the J 8087 with a micrometer and record the reading.

4. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
5. Subtract the piston diameter measurement from the cylinder bore diameter measurement in order to determine piston-to-bore clearance. Refer to *Engine Mechanical Specifications (L31 VIN R)*.
6. If the proper clearance cannot be obtained, select another piston and measure the clearances.
If the proper fit cannot be obtained, the cylinder bore may require honing or boring.
7. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.

SIE-ID = 195097

Piston and Connecting Rod Assemble

Tools Required

J 24086-C Piston Pin Remover/Installer

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

Notice: SIO-ID = 38775 After the J 24086-C installer hub bottoms on the support assembly, DO NOT exceed 35 000 kPa (5,000 psi) or the tool may be damaged.

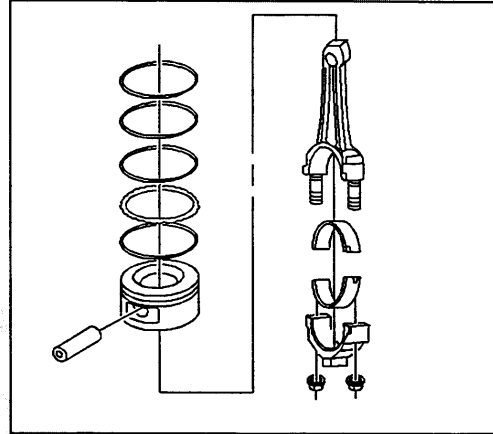
Important: When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.

The piston pin has an interference fit into the connecting rod and is full floating in the piston.

1. Install the piston pin and connecting rod assembly.
 - 1.1. Lubricate the piston and connecting rod pin bores with clean engine oil.
 - 1.2. Press the piston pin into the piston and connecting rod assembly using the *J 24086-C*.
 - 1.3. Inspect for the proper installation of the piston and piston pin.
The piston should move freely on the piston pin with no binding or interference.

Notice: *SIO-ID - 16608* Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

2. Install the piston rings onto the piston.
 - 2.1. Install the oil control ring spacer.
 - 2.2. Install the lower oil control ring.
 - 2.3. Install the upper oil control ring.
 - 2.4. Install the lower compression ring.
The mark on the side of the piston ring should face the top of the piston.
 - 2.5. Install the upper compression ring.
The mark on the side of the piston ring should face the top of the piston.
3. Space the compression ring end gaps 120 degrees apart.
4. Space the oil control ring end gaps a minimum of 90 degrees apart.



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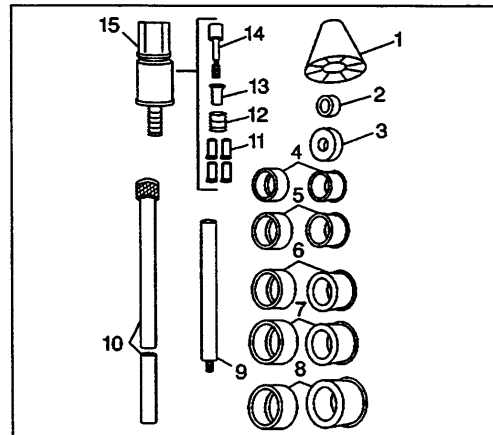
SIE-ID - 195130

Camshaft Bearing Removal

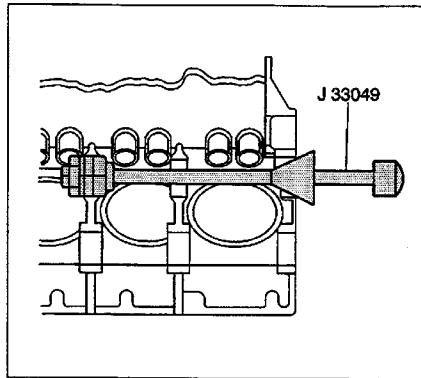
Tools Required

J 33049 Camshaft Bearing Service Set

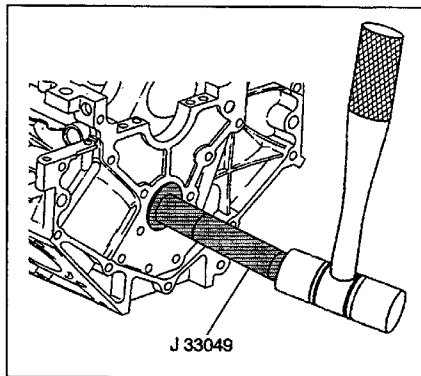
1. Select the cone (1), handle (10), expanding driver (4-8), and the washers (2 and 3) from the *J 33049*.
2. Assemble the *J 33049*.



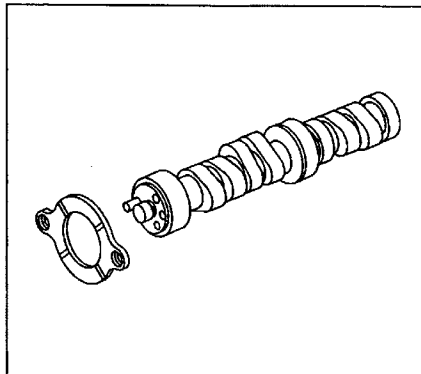
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Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block camshaft bearing bore.

3. Prior to camshaft bearing removal, inspect the camshaft bearings for loose fit in the engine block camshaft bearing bores.

Important: Remove the inner camshaft bearings #2, #3, and #4 first. The outer camshaft bearings #1 and #5 serve as a guide for the J 33049.

4. Insert the J 33049 through the front of the engine block and into the camshaft bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone into the front camshaft bearing to align the J 33049.
7. Drive the inner camshaft bearings from the camshaft bearing bores.

8. Assemble the J 33049 handle, the expanding driver, and the washer.

9. Insert the J 33049 into the engine block end camshaft bearings #1 or #5.

10. Remove the camshaft bearings from the camshaft bearing bores using the J 33049.

SIE-ID - 32912

Camshaft and Bearings Clean and Inspect

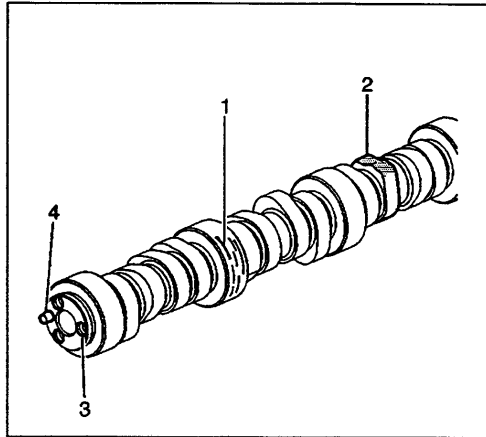
Tools Required

J 7872 Magnetic Base Dial Indicator

Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

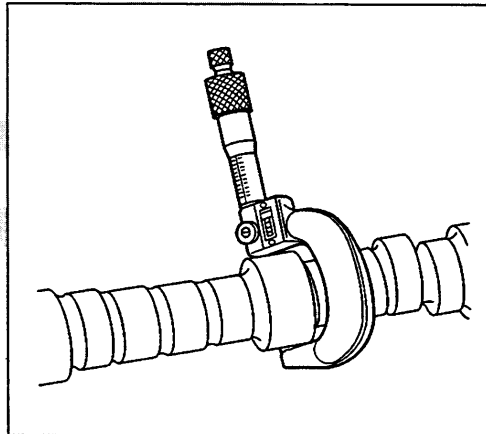
1. Clean the engine camshaft in cleaning solvent.
2. Dry the engine camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.

4. Inspect the engine camshaft for the following:
- Worn, scored, or damaged bearing journals (1)
 - Worn engine camshaft lobes (2)
 - Damaged bolt hole threads (3)
 - Damaged camshaft sprocket locator pin (4)



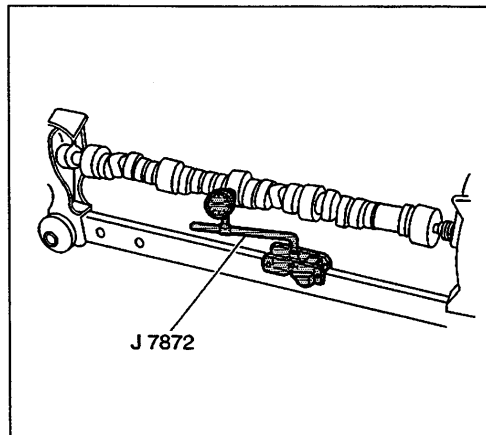
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5. Measure the engine camshaft journals with a micrometer.
- If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.

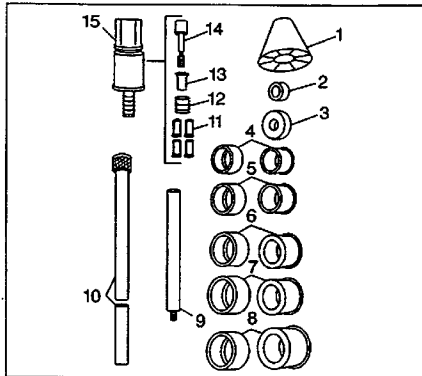


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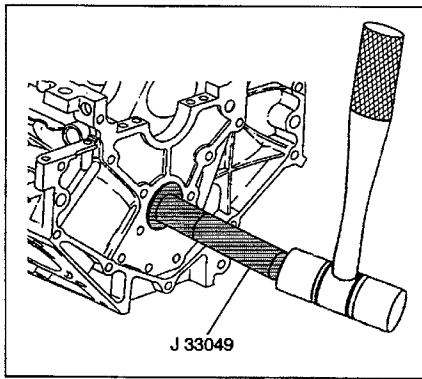
6. Measure for a bent engine camshaft or excessive engine camshaft runout using the J 7872.
- 6.1. Mount the engine camshaft in a suitable stand between centers.
- 6.2. Use the J 7872 in order to check the intermediate engine camshaft journals.
- If the runout exceeds 0.065 mm (0.0026 in), the engine camshaft is bent and should be replaced.
7. Measure the engine camshaft lobe lift using the J 7872.
- 7.1. Place the engine camshaft on the V-blocks.
- 7.2. Use the J 7872 in order to measure the engine camshaft lobe lift.
8. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications.



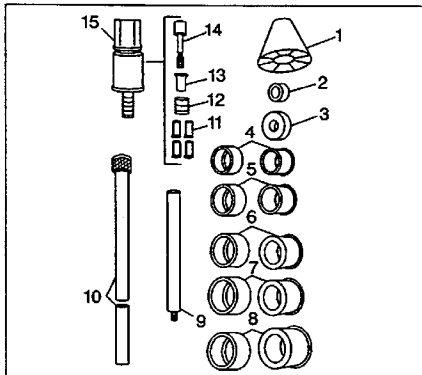
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SIE-10 - 195136

Camshaft Bearing Installation**Tools Required****J 33049 Camshaft Bearing Service Set**

1. Assemble the *J 33049* handle, the expanding driver, and the washer.

Important: The outer camshaft bearings #1 and #5 must be installed first. These camshaft bearings serve as guides for the *J 33049* and help center the inner camshaft bearings during the installation process.

Ensure the correct camshaft bearing fits into the proper bore. The camshaft bearing bores may vary in size.

Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the engine block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the camshaft bearing and the engine camshaft journal.

2. Install the camshaft bearing #1 into the engine block camshaft bearing bore using the *J 33049*.
3. Install the camshaft bearing #5 into the engine block camshaft bearing bore using the *J 33049*.
4. Select the expanding driver (4-8) and washer (2 and 3) using *J 33049*.
5. Assemble the *J 33049*.

6. Insert the *J 33049* through the front of the engine block and to the inner camshaft bearing bores #2, #3, and #4.
7. Install the camshaft bearing onto the expanding driver.
8. Tighten the expander assembly nut until the *J 33049* is snug in the camshaft bearing.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the camshaft bearing and the engine camshaft journal.

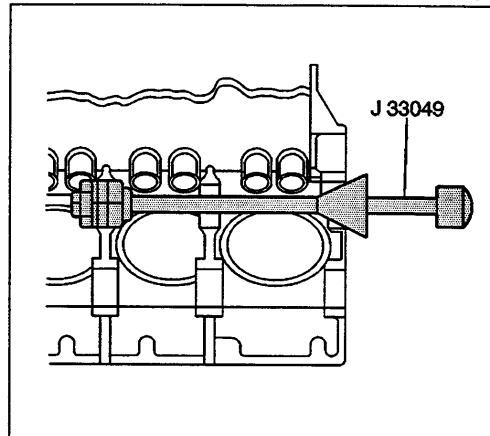
9. Align the oil lubrication hole in the camshaft bearing with the oil galleries in the engine block.
10. Push the guide cone into the front camshaft bearing bore to align the *J 33049*.
11. Drive the camshaft bearing into the engine block camshaft bearing bore.
12. Remove the *J 33049*.

SIE-ID = 195154

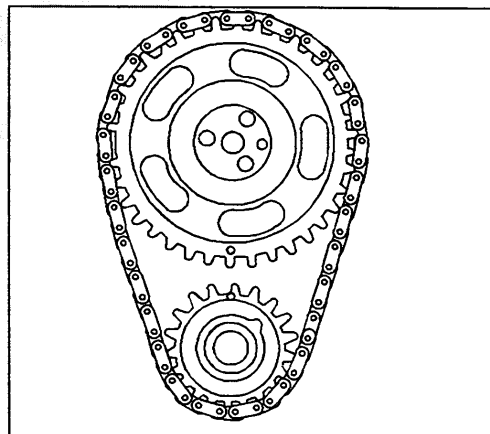
Timing Chain and Sprockets Clean and Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

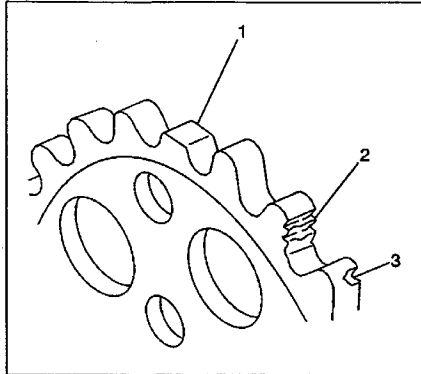
1. Clean the components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.



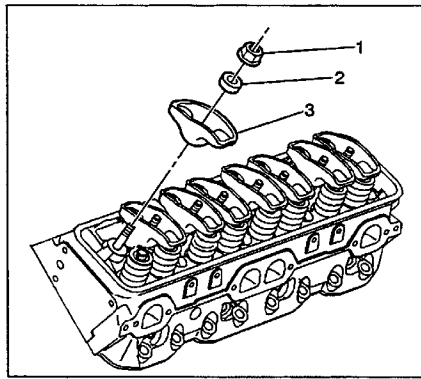
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4. Inspect the camshaft and crankshaft sprockets for:
- Broken teeth (1)
 - Damaged teeth (2)
 - Chipped teeth (3)
 - Worn teeth
 - Uneven wear on one edge of the teeth
 - Worn valleys between the sprocket teeth
 - Crankshaft sprocket keyway for wear
 - Woodruff key (crankshaft sprocket) for wear or damage

SIE-ID - 195201

Valve Rocker Arm and Push Rods Clean and Inspect

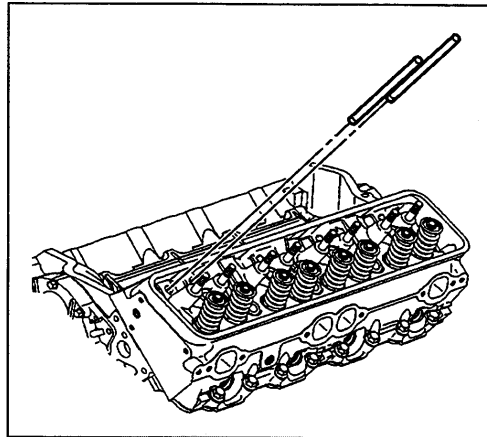
Caution: SIO-ID - 8011 *Wear safety glasses in order to avoid eye damage.*

Important: Parts that are to be reused must be marked, sorted and organized for assembly.

1. Mark, sort, and organize the components for assembly.
2. Clean the components with cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve rocker arms (3) for wear or scoring in the ball area.
5. Inspect the valve rocker arm (3) pushrod sockets and valve stem mating surfaces for wear or scoring.
6. Inspect the valve rocker arm ball (2) for wear or scoring.

The surfaces should be smooth with no scoring or exceptional wear.

7. Inspect the valve pushrods for worn or scored ends.
The surfaces should be smooth with no scoring or exceptional wear.
8. Inspect the valve pushrods for bends. Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.
9. Inspect the valve pushrod oil passages for restrictions.



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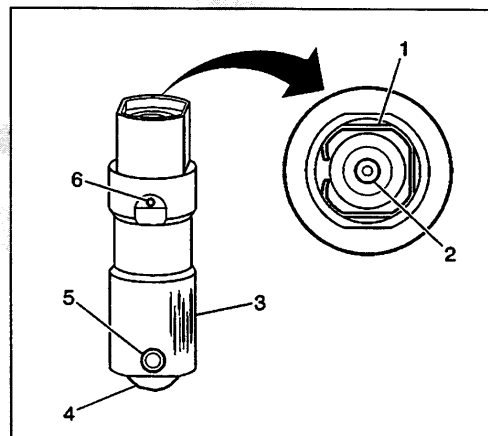
SIE-ID = 195248

Valve Lifters and Guides Clean and Inspect

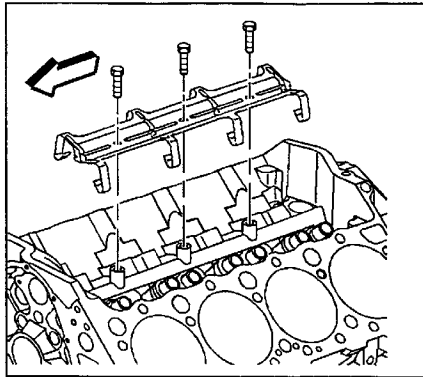
Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

Important: Components that are to be reused must be marked, sorted, and organized for assembly.

1. Mark, sort, and organize the components for assembly.
2. Clean the components in cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve lifter for the following:
 - Broken or damaged clip (1)
 - Worn valve pushrod socket (2)
 - Wear or scuffing (3)
 If the valve lifter shows wear or scuffing, inspect the engine block valve lifter bores for wear or damage.
 - Worn roller (4)
 - Loose or damaged pin (5)
 - Plugged oil hole (6)

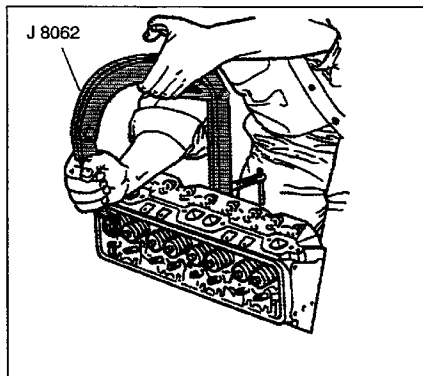


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5. Inspect the valve lifter guides for excessive wear.
6. Inspect the valve lifter guides for cracks or damage.
7. Inspect the valve lifter guide retainer for:
 - Wear, damage, or stress cracking in the leg areas
 - Wear or damage in the bolt holes



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SIE-ID - 195340

Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor

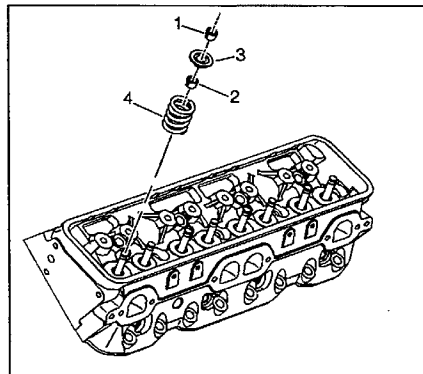
Caution: SIO-ID - 411464 *Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.*

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Use the J 8062 in order to compress the valve springs.

Important: Place the valves in a rack, in the proper sequence, so that the valves can be installed in the same order as the valve were removed.

2. Remove the valve stem keys (1).
3. Remove the J 8062 from the cylinder head.
4. Remove the valve spring cap (3).
5. Remove the valve spring (4).
6. Remove the valve stem oil seal (2).
7. Discard the valve stem oil seal.
8. Remove the valve.



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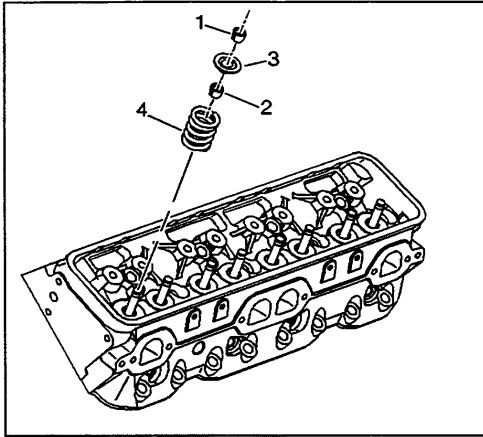
SIE-ID = 69069

Cylinder Head Clean and Inspect**Tools Required**

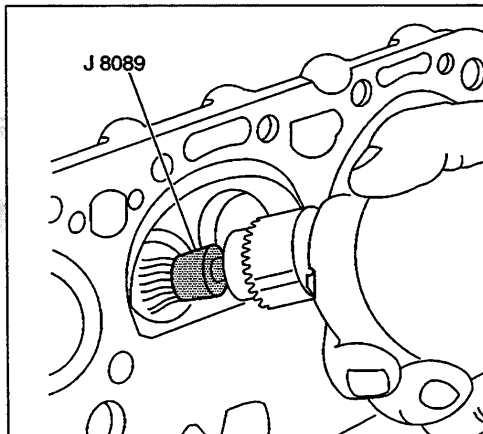
- J 8001 Dial Indicator Set
- J 8089 Carbon Removing Brush
- J 9666 Valve Spring Tester

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

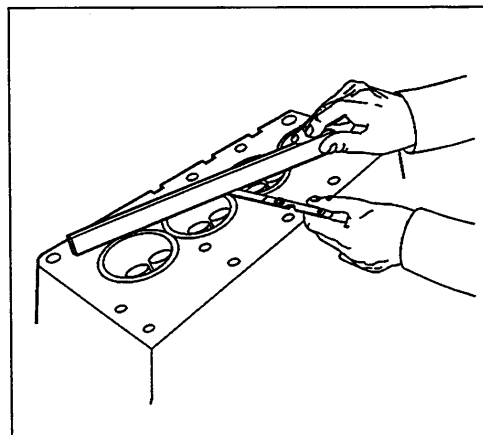
1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:
 - Valve stem keys (1)
 - Valve spring cap (3)
 - Valve spring (4)
 - Cylinder head
3. Dry the components with compressed air.
4. Use the J 8089 to clean the carbon from the cylinder head combustion chambers. Be careful not to scuff the combustion chambers.
5. Inspect the cylinder head for the following:
 - Damage to the gasket surfaces
 - Damage to the threaded bolt holes
 - Burnt or eroded areas in the combustion chamber
 - Cracks in the exhaust ports and combustion chambers
 - External cracks in the water chamber
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged, or leaking core plugs
6. Measure the cylinder head for warpage with a straight edge and feeler gauge.
 - A cylinder head block deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
 - A cylinder head exhaust manifold deck with warpage in excess of 0.5 mm (0.002 in) must be repaired or replaced.
 - A cylinder head intake manifold deck with warpage in excess of 0.10 mm (0.004 in) must be repaired or replaced.



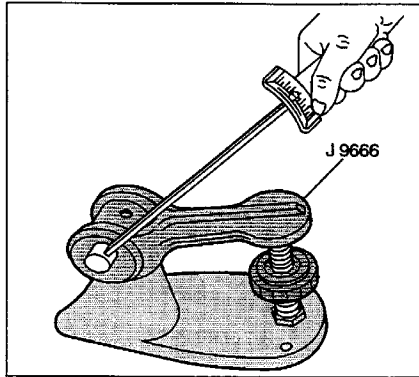
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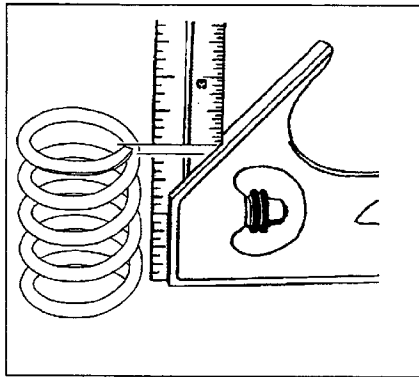
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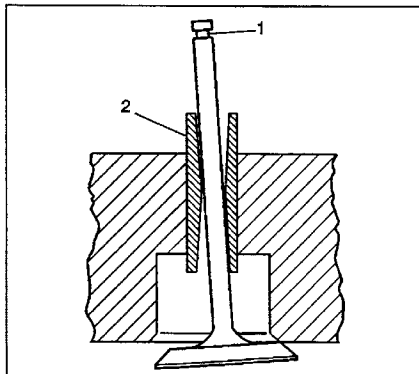
7. Use the J 9666 in order to measure the valve spring.

Replace the valve spring if the valve spring tension is less than 338 N (76 lb) at 43.2 mm (1.70 in).



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8. Inspect the valve springs for squareness.



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9. Valve stems (1) with excessive guide (2) clearance must be repaired or replaced.

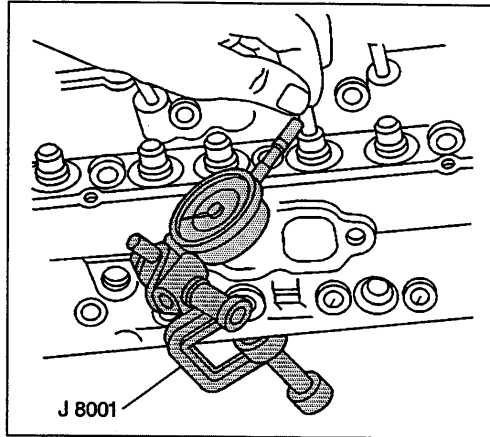
10. Measure the valve stem-to-guide clearance.

Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

- 10.1. Clamp the *J 8001* on the exhaust port side of the cylinder head.
- 10.2. Locate the dial indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the dial indicator stem.

The dial indicator stem must contact the side of the valve stem just above the valve guide.

- 10.3. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.
- 10.4. Use light pressure and then move the valve stem from side to side in order to obtain a clearance reading. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.

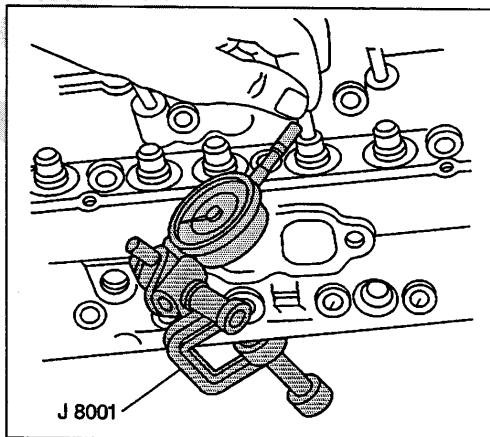


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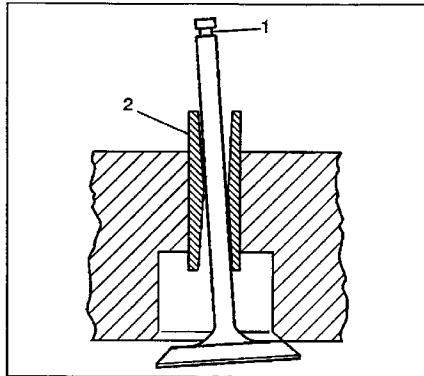
SIE-ID - 69806

Valve Guide Reaming/Valve and Seat Grinding**Tools Required***J 8001* Dial Indicator Set

1. Measure the valve stem-to-guide clearance. Refer to *Cylinder Head Clean and Inspect*.

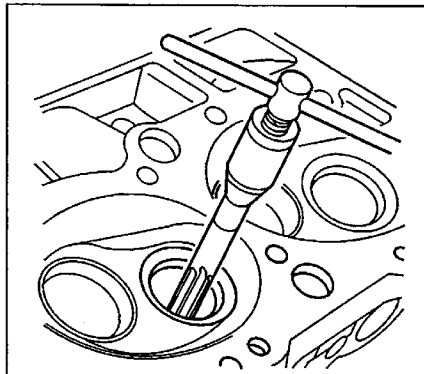


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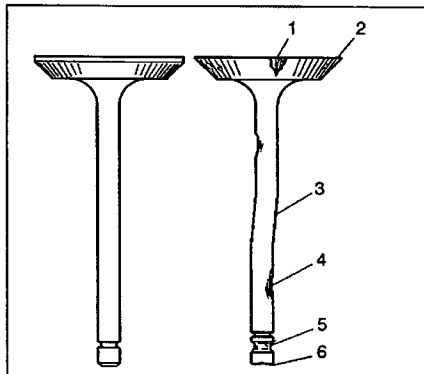
2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.



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Caution: S10-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

3. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance.
 - 3.1. Ream the valve guide oversize to accept a valve guide sleeve.
 - 3.2. Insert the valve guide sleeve into the valve guide bore.
 - 3.3. Ream the sleeve to achieve proper valve stem-to-guide clearance.
4. Always recondition the valve and the valve seat after reaming the valve guide bores or installing new valves.



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5. Inspect the valves for the following:
 - Burnt or damaged areas (1)
 - Undersized margin (2)
 - Bent stem (3)
 - Scoring or other damage to the stem (4)
 - Worn key groove (5)
 - Worn stem tip (6)

6. Inspect the valve contact surface for the following:

- Undersized margin (1)
- Pitted surface (2)
- Burnt or eroded areas (3)
- Acceptable edge (margin) (4)

Valves with excessive damage must be replaced.

Minor imperfections of the valve or valve seat may be repaired.

7. Reconditioning of the valves and valve seats:

- The valves must seat perfectly for the engine to deliver optimum power and performance.
- Cooling the valve heads is another important factor. Good contact between each valve and valve seat in the cylinder head is necessary to insure that the heat in the valve head is properly carried away.
- Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the valve guide.

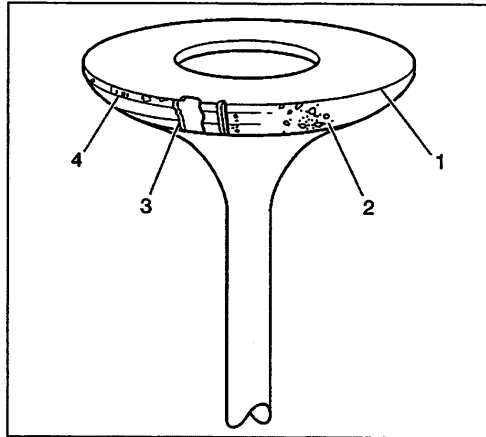
The valve seats should be concentric to within 0.05 mm (0.031 in) total indicator reading.

- Reface pitted valves on a valve refacing machine in order to insure the correct relationship between the valve head and the valve stem.

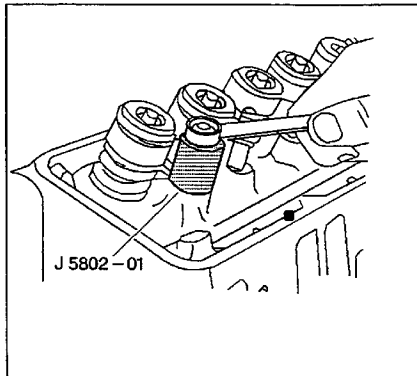
Replace the valve stems that show excessive wear or are warped.

Replace the valve if the edge of the valve head is less than 0.79 mm (0.031 in) thick after grinding.

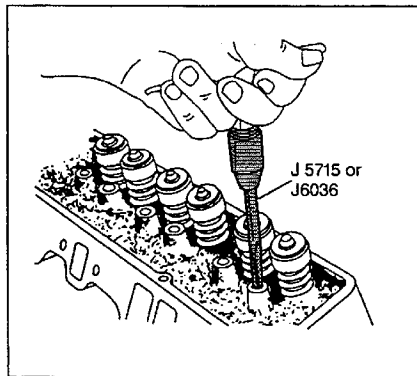
- Several different types of equipment are available for reconditioning valves and valve seats. Follow the manufacturer's recommendations for equipment use to attain the proper results.



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SIE-ID = 195352

Valve Rocker Arm Stud Removal**Tools Required***J 5802-01* Rocker Arm Stud Remover

Valve rocker arm ball studs that have damaged threads or are loose in cylinder heads should be replaced.

Valve rocker arm ball studs are pressed into the cylinder head.

New valve rocker arm ball studs are available in 0.0762 mm (0.003 in) and 0.3302 mm (0.013 in) oversize.

1. Place the *J 5802-01* over the valve rocker arm ball stud to be removed.
2. Install a nut and a flat washer.
3. Rotate the nut clockwise to remove the valve rocker arm ball stud.

SIE-ID = 195354

Valve Rocker Arm Stud Installation**Tools Required**

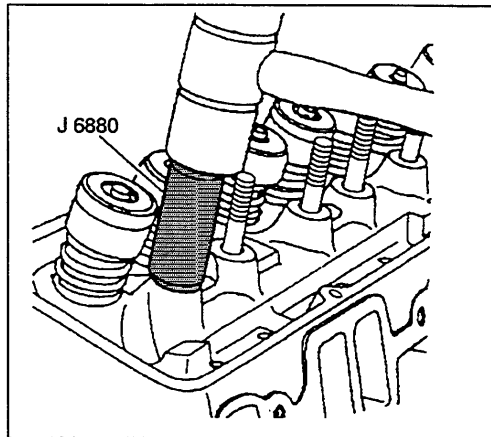
- *J 5715* Reamer (0.0762 mm (0.003 in))
- *J 6036* Reamer (0.03302 mm (0.013 in))
- *J 5802-01* Rocker Arm Stud Installer

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

Important: Valve rocker arm ball studs that have damaged threads or are loose in cylinder heads should be replaced. New valve rocker arm ball studs are available in 0.0762 mm (0.003 in) and 0.3302 mm (0.013 in) oversize.

1. Ream the hole to the proper size for the replacement oversize valve rocker arm ball stud.
Use *J 5715* for 0.0762 mm (0.003 in) oversize valve rocker arm ball studs, or *J 6036* for 0.3302 mm (0.013 in) oversize valve rocker arm ball studs.
2. Apply lubricant GM P/N 1052271 or equivalent the lower end (press-fit end) of the valve rocker arm ball stud.

3. Use the *J 6880* and a hammer to install the valve rocker arm ball stud into place. The valve rocker arm ball stud is installed to proper depth when the *J 6880* bottoms onto the cylinder head.



66504

SIE-ID # 195342

Cylinder Head Assemble

Tools Required

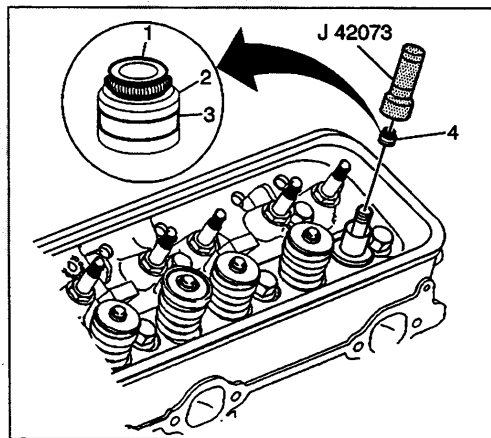
- *J 8062* Valve Spring Compressor
- *J 42073* Valve Stem Seal Installer

Caution: SIO-ID # 5011 **Wear safety glasses in order to avoid eye damage.**

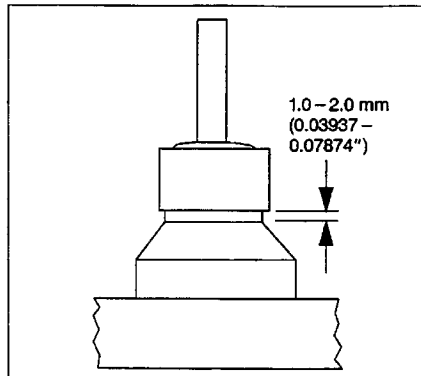
Important: The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal.

1. Assemble the valve into the proper valve guide.
2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and guide with clean engine oil GM P/N 12345610 or equivalent.
4. Assemble the valve stem oil seal onto the valve stem.
5. Install the valve stem oil seal onto the valve guide using the *J 42073*.

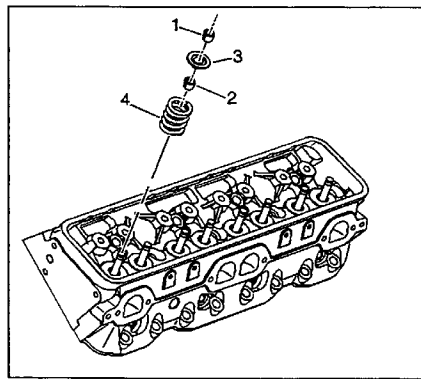
Install the valve stem oil seal onto the valve guide until the *J 42073* bottoms against the valve spring seat.



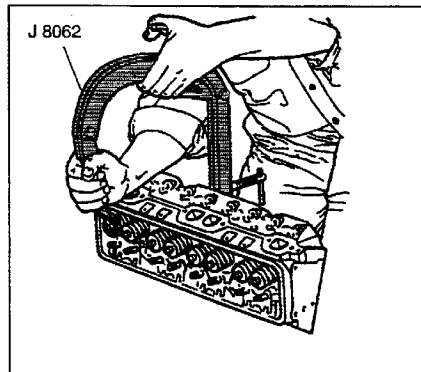
200320



36373



69538



34468

6. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

There should be a
1-2 mm (0.03937-0.07874 in) gap between the
bottom edge of the valve stem oil seal and the
valve guide.

7. Install the valve spring (4).
8. Install the valve spring cap (3) onto the valve
spring (4) and over the valve stem.

Caution: S10-ID = 411464 **Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.**

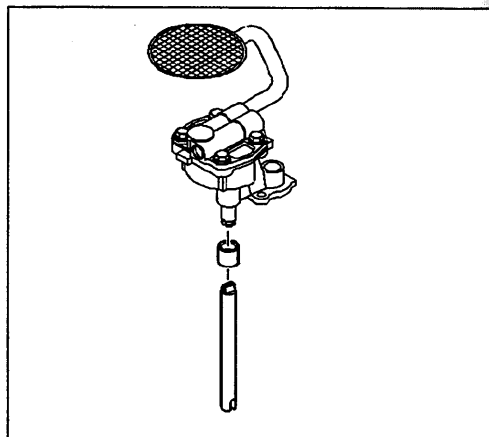
9. Use the J 8062 in order to compress the valve spring.
10. Install the valve stem keys.
10.1. Use grease in order to hold the valve stem keys in place while disconnecting the J 8062.
10.2. Ensure that the valve stem keys seat properly in the upper groove of the valve stem.
10.3. Tap the end of the valve stem with a

plastic-faced hammer in order to seat the valve stem keys, if necessary.

SIE-ID - 195049

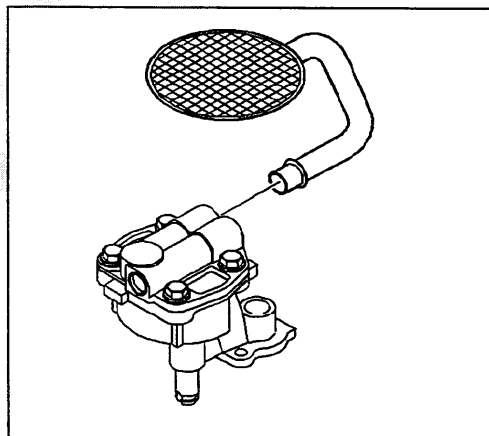
Oil Pump Disassemble

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

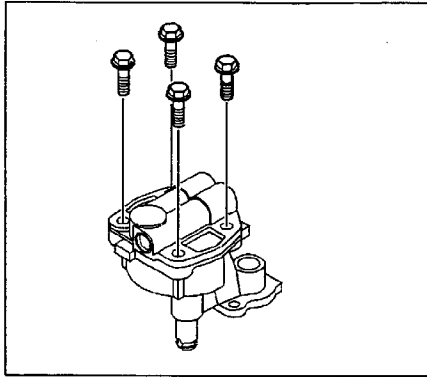


5274

2. Remove the oil pump screen (If necessary).
 - The oil pump screen has a press fit into the oil pump cover.
 - DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

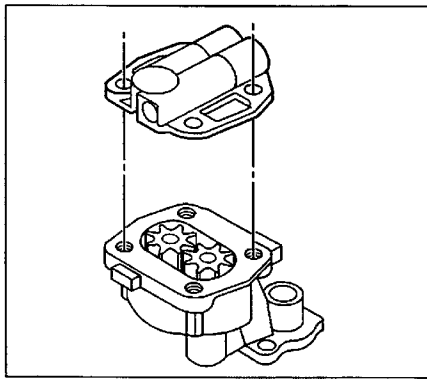


5275



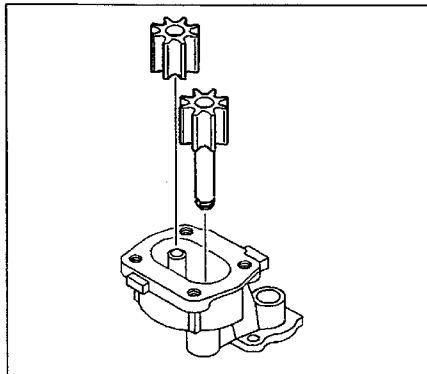
5276

3. Remove the oil pump cover bolts.



5277

4. Remove the oil pump cover.

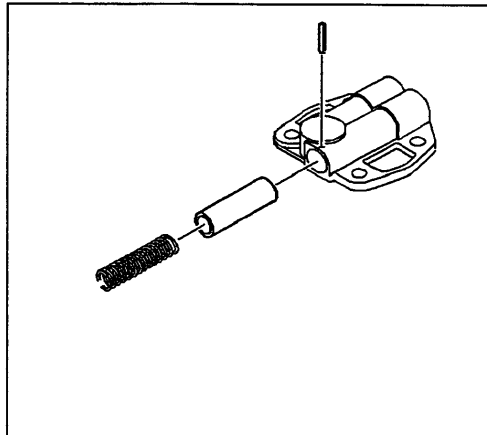


5278

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

7. Remove the following items:
 - 7.1. The oil pump pressure relief valve spring straight pin
 - 7.2. The oil pump pressure relief spring
 - 7.3. The oil pump pressure relief valve



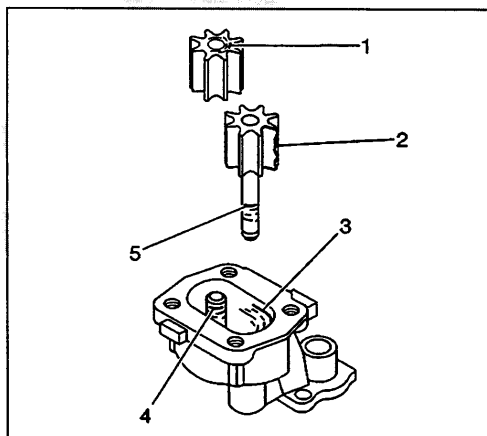
30401

SIE-ID - 35473

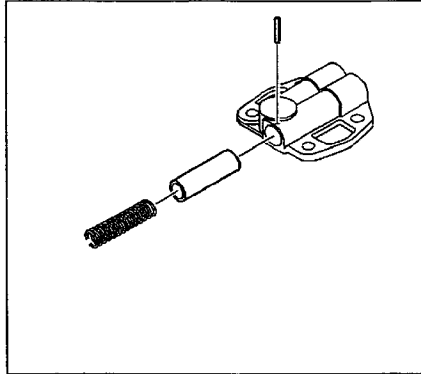
Oil Pump Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

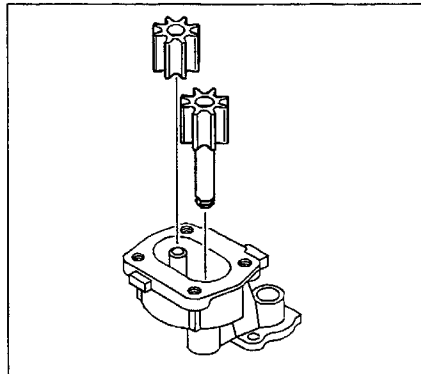
1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
 - Scoring, damage or casting imperfections to the body (3)
 - Damaged gears (2) for
 - Chipping
 - Galling
 - Wear
 - Scoring on the top of the gears (1)
 - Damaged or scored gear shaft (5)
 - Damaged bolt hole threads
 - Worn oil pump driveshaft bore
 - Damaged or sticking oil pump pressure relief valve (minor imperfections may be removed with a fine oil stone).
 - Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
5. During oil pump installation, install a NEW oil pump driveshaft retainer.



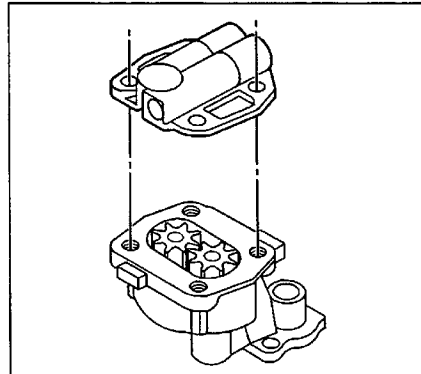
186750



30401



5278



5277

SIE-ID = 389671

Oil Pump Assemble**Tools Required****J 21882** Oil Suction Pipe Installer

1. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump pressure relief valve, oil pump pressure relief valve spring, and oil pump body.

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

Important: Replace the oil pump pressure relief valve spring when you reuse the oil pump.

2. Install the following items:
 - 2.1. The oil pump pressure relief valve
 - 2.2. The oil pump pressure relief valve spring
 - 2.3. The oil pump pressure relief valve spring straight pin
3. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump drive gear, the oil pump driven gear, and the oil pump body internal surfaces.
4. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
 - 4.1. Align the matchmarks on the oil pump drive and driven gears.
 - 4.2. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.

5. Install the oil pump cover.

Engine

Engine Mechanical - 5.0L, 5.7L 6-199

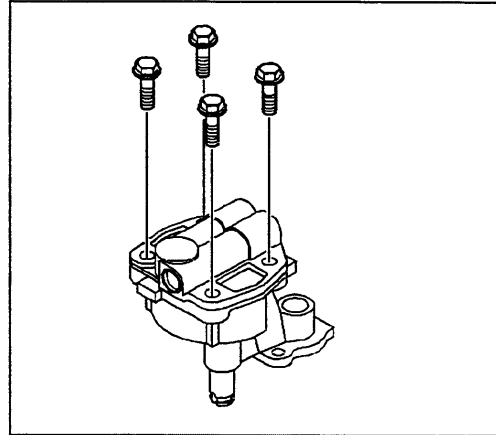
Notice: Refer to *Fastener Notice* in Caution and Notices.

6. Install the oil pump cover bolts.

Tighten

Tighten the bolts to 12 N.m (106 lb in).

7. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.



5276

8. Install the oil pump screen.

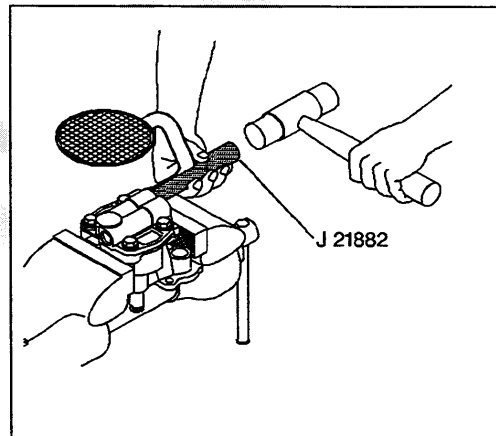
- 8.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.

- 8.2. Mount the oil pump in a soft jawed vise.

- 8.3. Apply sealant GM P/N 12346004 or equivalent to the end of the oil pump screen pipe.

- 8.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body.

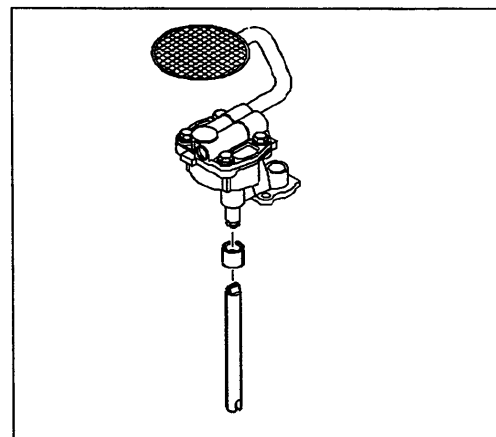
The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.



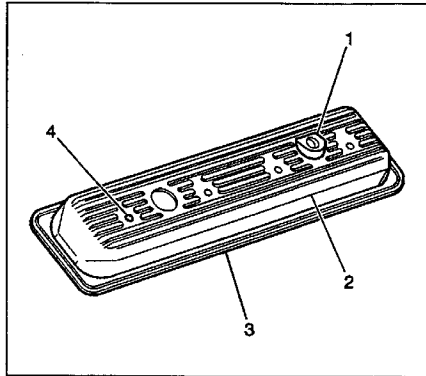
5280

Important: Install a NEW oil pump driveshaft retainer during assembly.

9. Install the oil pump driveshaft and the NEW oil pump driveshaft retainer.



5274



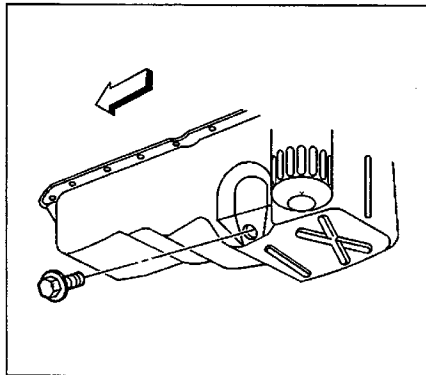
333657

SIE-ID = 195020

Valve Rocker Arm Cover Clean and Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the valve rocker arm cover in cleaning solvent.
2. Dry the valve rocker arm cover with compressed air.
3. Inspect the valve rocker arm cover for the following:
 - Damage to the PCV valve grommet (1)
 - Dents or damage to the exterior of the valve rocker arm cover (2)
 - A dented or damaged cover may interfere with the valve rocker arms.
 - Gouges or damage to the sealing surface (3)
 - Damage to the bolt holes (4)
 - Restrictions to the ventilation system passages



182850

SIE-ID = 194998

Oil Pan Clean and Inspect

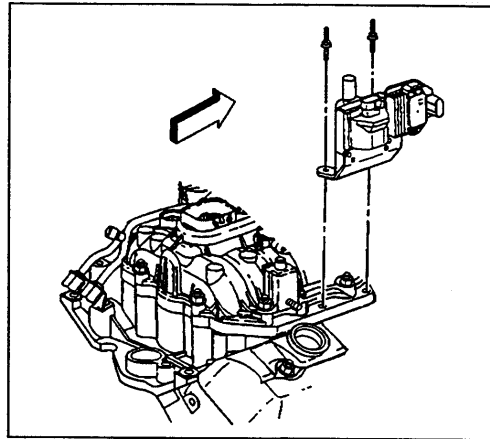
Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the oil pan in cleaning solvent.
2. Dry the oil pan with compressed air.
3. Inspect the oil pan for the following:
 - The oil pan drain plug hole for damaged threads.
 - Gouges or damage to the oil pan sealing surfaces
 - Damage to the oil pan baffle
 - Dents or damage to the exterior of the oil pan
 - An oil pan that is dented may interfere with the position of the oil pump screen or not distribute oil properly in the oil pan sump area.

SIE-ID = 193478

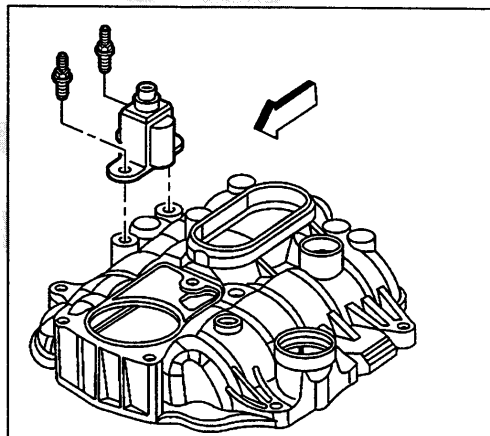
Intake Manifold Disassemble

1. Remove the studs and the ignition coil.



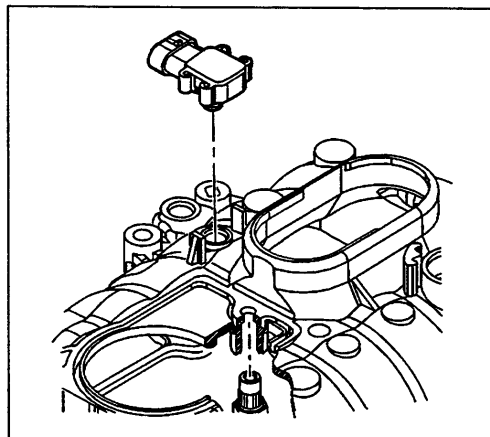
31466

2. Remove the studs and the evaporative emission (EVAP) canister purge solenoid valve.

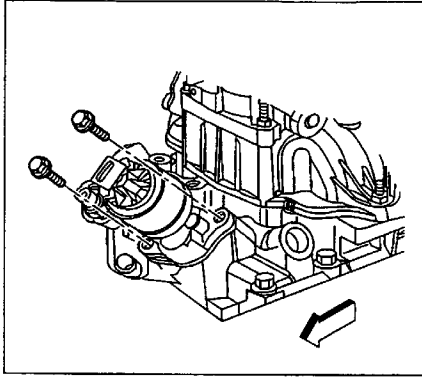


334511

3. Remove the manifold absolute pressure (MAP) sensor and the upper intake manifold.
4. Remove the seal (O-ring) from the MAP sensor and discard.



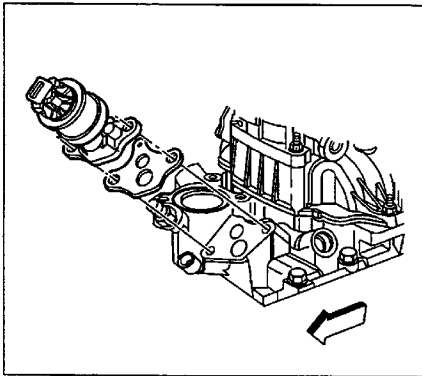
10933



22075

Important: Note the position and direction of the exhaust gas recirculation (EGR) valve before removal. It is possible to improperly install the EGR valve 180 degrees from the original position.

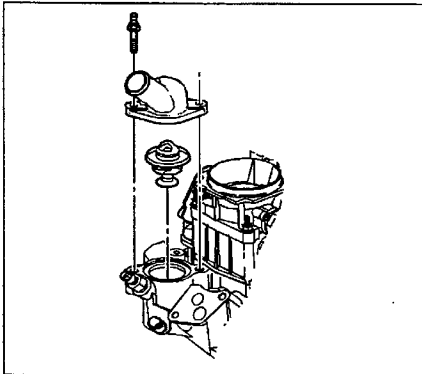
5. Remove the exhaust gas recirculation (EGR) valve bolts.



22076

Notice: *510-ID - 5005* The Linear EGR valve is an electrical component. DO NOT soak in any liquid cleaner or solvent because damage may result.

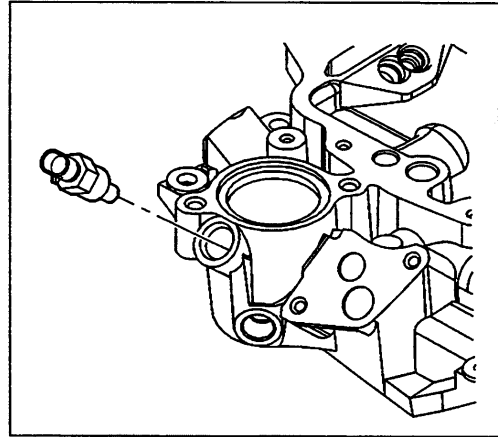
6. Remove the EGR valve and gasket from the lower intake manifold.
7. Discard the EGR valve gasket.



48323

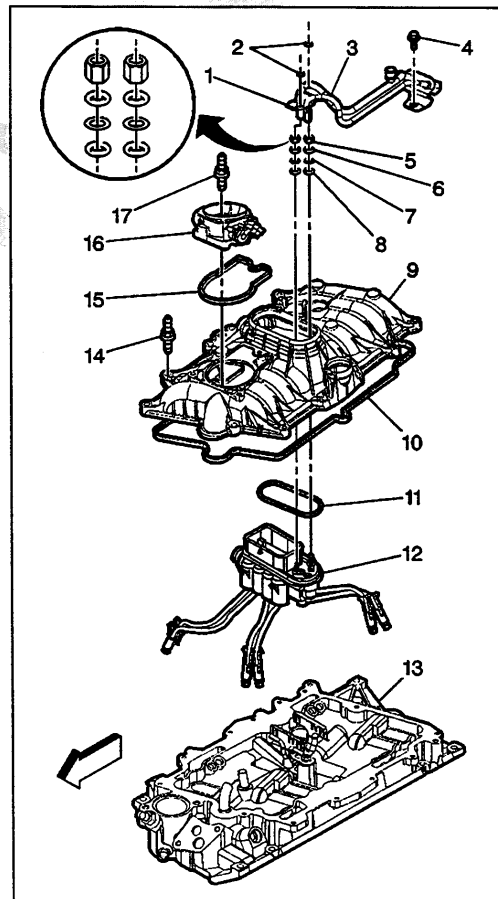
8. Remove the water outlet studs.
9. Remove the water outlet, the engine coolant thermostat, and the engine coolant thermostat seal (O-ring).
10. Discard the engine coolant thermostat seal (O-ring).

11. Remove the engine coolant temperature (ECT) sensor from the lower intake manifold.

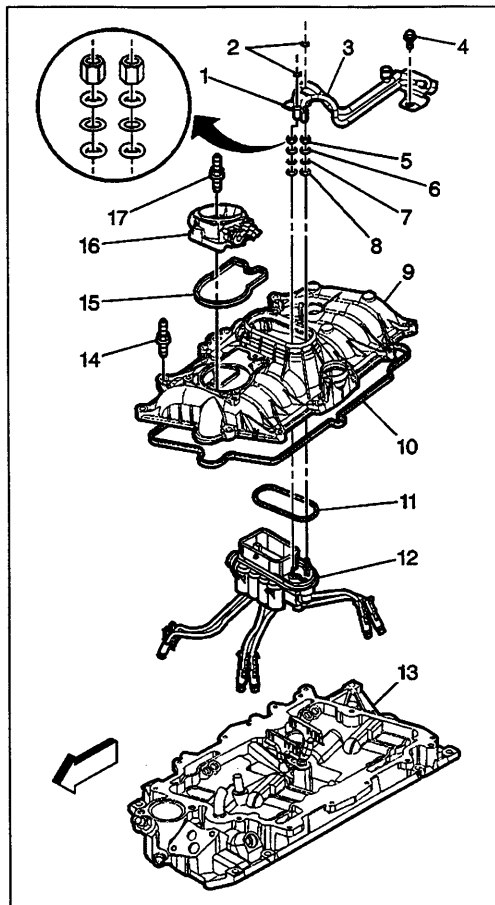


10932

12. Remove the throttle body attaching studs (17).
13. Remove the throttle body (16) and the throttle body gasket (15).
14. Discard the throttle body gasket (15).
15. Remove the fuel pipe bolt (4).
16. Remove the nuts (2) and the fuel pipe retainer (1).
17. Remove the fuel pipe (3).
18. Remove and discard the fuel seal retainers (5).
19. Remove and discard the fuel seals (6) (yellow O-rings).
20. Remove and discard the spacer rings (7) (flat washers).
21. Remove and discard the fuel seals (8) (black O-rings).
22. Remove the upper intake manifold studs (14).
23. Remove the upper intake manifold (9) and the upper intake manifold to lower intake manifold gasket (10).
24. Discard the upper intake manifold to lower intake manifold gasket (10).
25. Remove the TBI fuel meter (12) and fuel meter body seal (11).
26. Discard the fuel meter body seal (11).



66929



66929

SIE-ID = 66845

Intake Manifold Clean and Inspect

SIO-ID = 66893

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the upper intake manifold (9) and the lower intake manifold (13) in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the upper intake manifold (9) for the following:
 - Cracks or other damage to the exterior
 - Cracking or damage in the gasket grooves
 - Loose or damaged bolt hole thread inserts
 - Damage to the throttle body mounting surface
4. Inspect the lower intake manifold (13) for the following:
 - Cracks or damage
 - Damage to the gasket sealing surfaces
 - Damage to the threaded bolt holes
 - Restricted exhaust gas recirculation (EGR) system passages
 - Restricted cooling system passages

SIE-ID # 194513

Intake Manifold Assemble

1. Install the TBI fuel meter (12) into the lower intake manifold (13).
2. Install the NEW fuel meter body seal (11) into the groove on the TBI fuel meter (12).
3. Install the NEW upper intake manifold to lower intake manifold gasket (10) into the groove of the upper intake manifold (9).
4. Install the upper intake manifold (9) (with gasket) onto the lower intake manifold (13).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the upper intake manifold studs (14).

Tighten

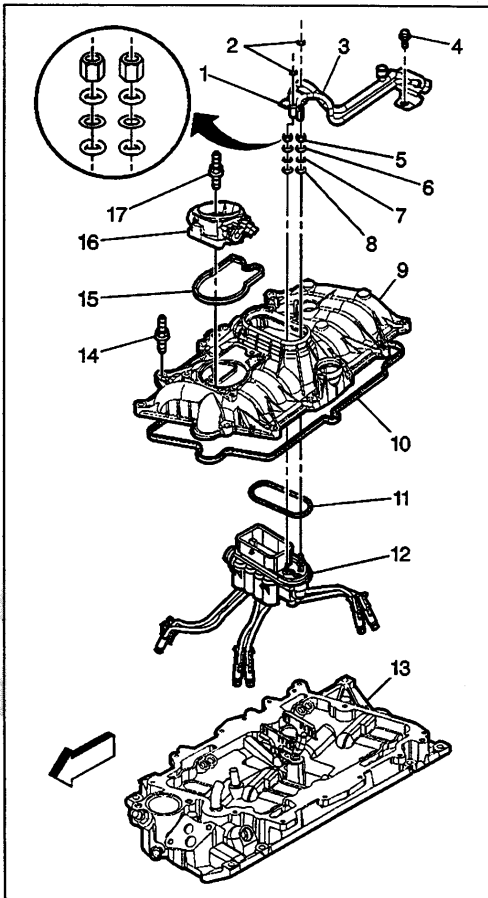
- 5.1. Tighten the upper intake manifold studs on the first pass to 5 N.m (44 lb in).
- 5.2. Tighten the upper intake manifold studs on the second pass to 10 N.m (88 lb in).
6. Install the NEW fuel seals (8) (black O-rings) into the TBI fuel meter (12).
7. Install the NEW spacer rings (7) (flat washers) into the TBI fuel meter (12).
8. Install the NEW fuel seals (6) (yellow O-rings) into the TBI fuel meter (12).
9. Install the NEW fuel seal retainers (5) into the TBI fuel meter (12).
10. Install the fuel pipe (3) into the TBI fuel meter (12).
11. Install the fuel pipe retainer (1) and the nuts (2).
12. Install the fuel pipe bolt (4).

Tighten

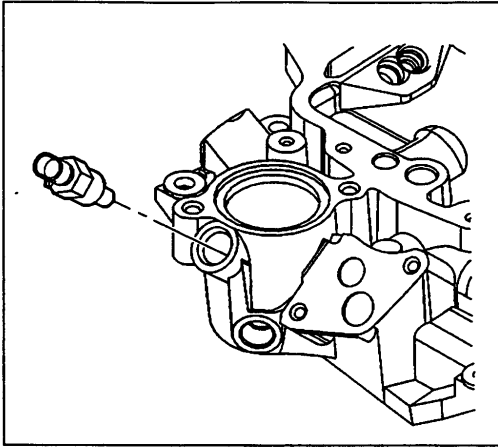
- 12.1. Tighten the fuel pipe bolt to 6 N.m (53 lb in).
- 12.2. Tighten the fuel pipe retainer nuts to 3 N.m (27 lb in).
13. Install a NEW throttle body gasket (15) into the groove of the upper intake manifold (9).
14. Install the throttle body (16) and attaching studs (17).

Tighten

Tighten the throttle body attaching studs to 9 N.m (80 lb in).



66929



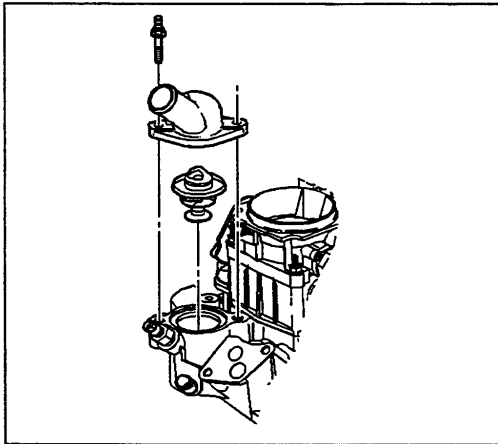
10932

15. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine coolant temperature (ECT) sensor.

16. Install the ECT sensor into the lower intake manifold.

Tighten

Tighten the ECT sensor to 20 N.m (15 lb ft).



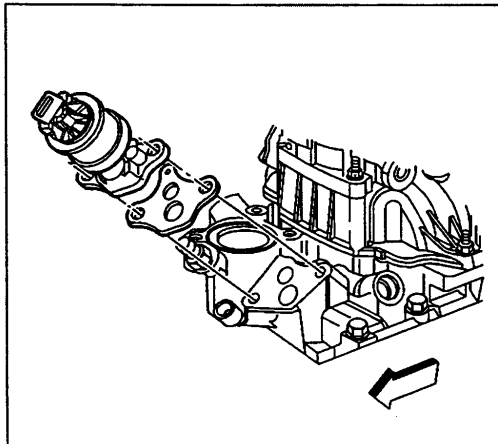
48323

17. Install the engine coolant thermostat and NEW engine coolant thermostat seal (O-ring) into the lower intake manifold.

18. Install the water outlet and studs.

Tighten

Tighten the water outlet studs to 25 N.m (18 lb ft).



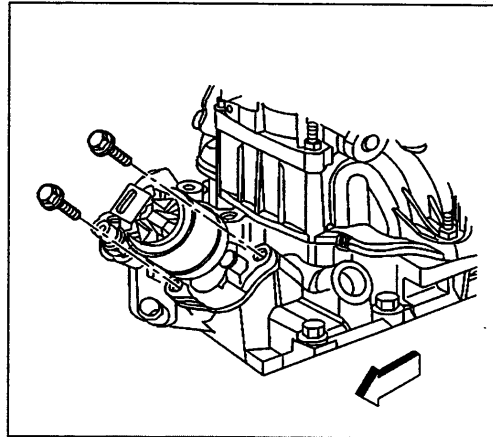
22078

19. Install the exhaust gas recirculation (EGR) valve and NEW EGR valve gasket to the lower intake manifold.

20. Install the EGR valve bolts.

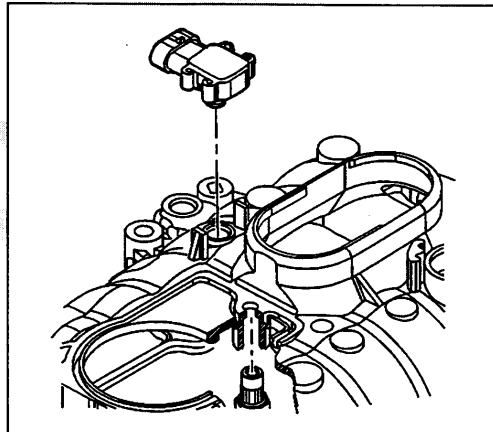
Tighten

- 20.1. Tighten the EGR valve bolts on the first pass to 10 N·m (88 lb in).
20.2. Tighten the EGR valve bolts on the final pass to 30 N·m (22 lb ft).



22075

21. Install a NEW manifold absolute pressure (MAP) sensor seal onto the MAP sensor.
22. Apply a small amount of clean engine oil GM P/N 12345610 or equivalent to the MAP sensor seal.
23. Install the MAP sensor into the upper intake manifold.

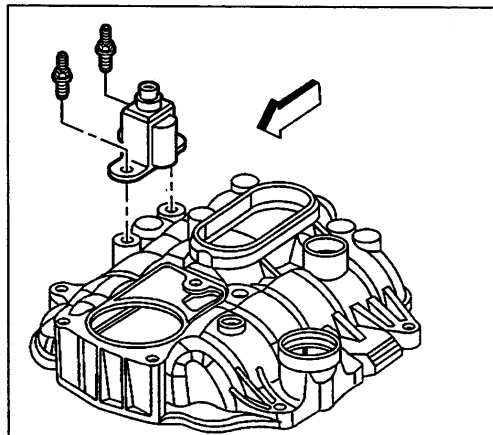


10933

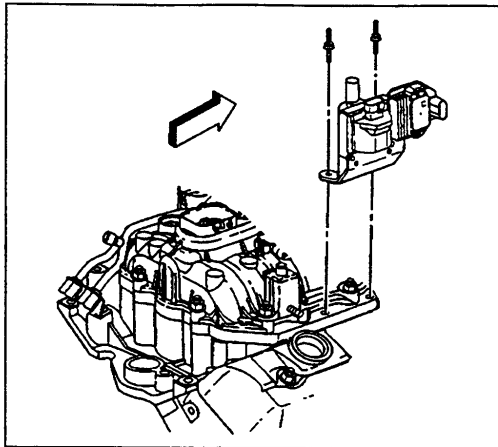
24. Install the evaporative emission (EVAP) canister purge solenoid valve and studs.

Tighten

Tighten the EVAP canister purge solenoid valve studs to 12 N·m (106 lb in).



334511

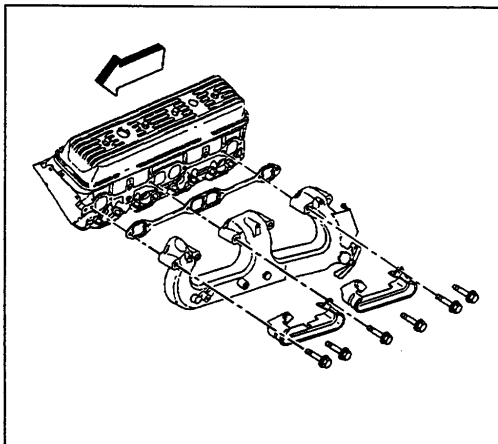


31466

25. Install the ignition coil and studs.

Tighten

Tighten the ignition coil studs to 12 N.m (106 lb in).



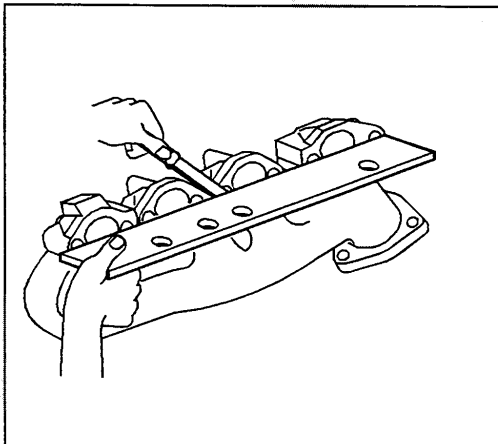
64925

SIE-ID - 69043

Exhaust Manifold Clean and Inspect

Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

1. Clean the exhaust manifolds in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
 - Damage to the gasket sealing surfaces
 - Damage to the exhaust gas recirculation (EGR) pipe fitting (left manifold)
 - Damage to the take down studs
 - Restrictions within exhaust passages
 - Broken or damaged exhaust manifold heat shields (if applicable)
 - Damaged or cracked exhaust manifold
4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gauge. Refer to *Engine Mechanical Specifications (L31 (VIN R))*.
If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.



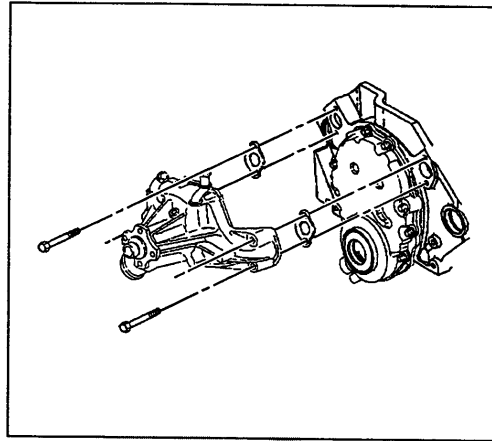
66607

SIE-ID - 194965

Water Pump Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
 - Gasket sealing surfaces for excessive scratches or gouging
 - Restrictions within the internal coolant passages
 - Excessive side-to-side play in the pulley shaft
 - Leakage at the water inlet pipe or housing rear cover gasket
 - Leakage at the water pump vent hole
A stain around the vent hole is acceptable. If leakage occurred (dripping) with the engine operating and the cooling system pressurized, then replace the water pump.
 - Damaged bolt hole threads



69011

SIE-ID - 43122

Service Prior to Assembly

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are re-installed into an engine, return the components to the original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). The engine oil will provide the initial lubrication when the engine is first started.

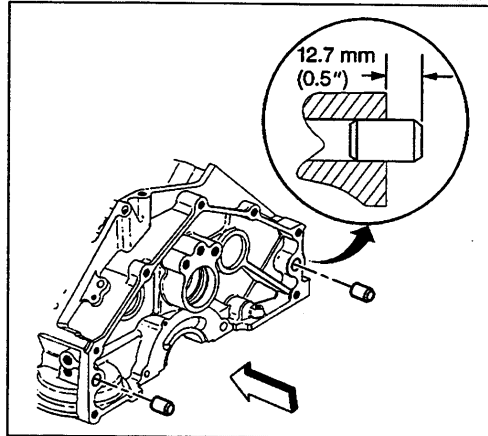
SIE-ID = 348917

Engine Block Plug Installation**Tools Required**

J 41712 Oil Pressure Switch Socket

1. Install the transmission locator pins (if required).

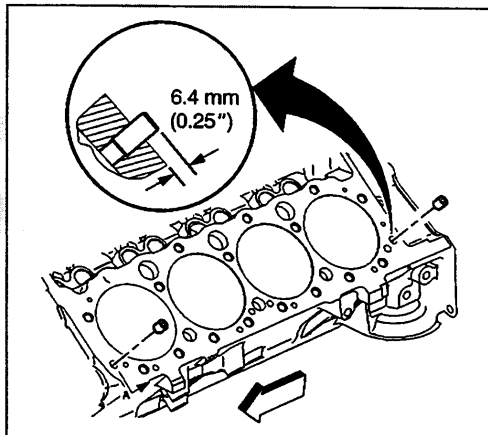
A properly installed transmission locator pin will protrude 12.7 mm (0.5 in) from the rear face of the engine block.



182855

2. Install the dowel pins (cylinder head locator) (if required).

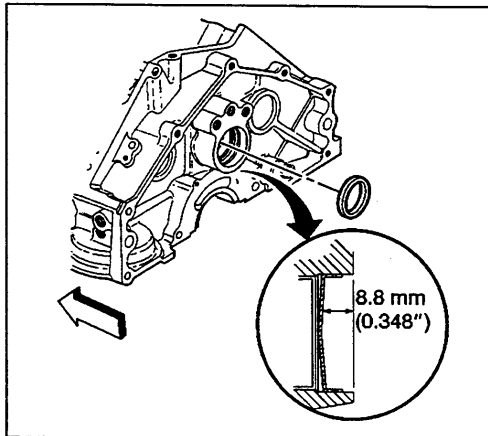
A properly installed dowel pin will protrude 6.4 mm (0.25 in) from the cylinder head deck surface of the engine block.



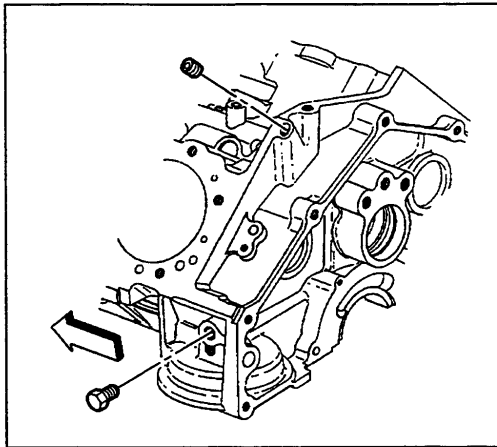
182846

3. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW expansion cup plug (camshaft rear bearing hole).
4. Install the NEW expansion cup plug (camshaft rear bearing hole).

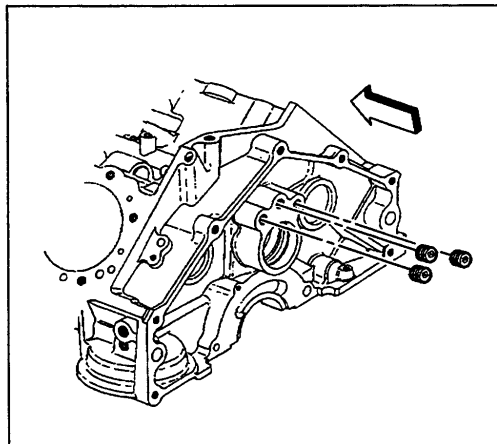
A properly installed expansion cup plug will be installed 8.8 mm (0.348 in) into the rear of the engine block.



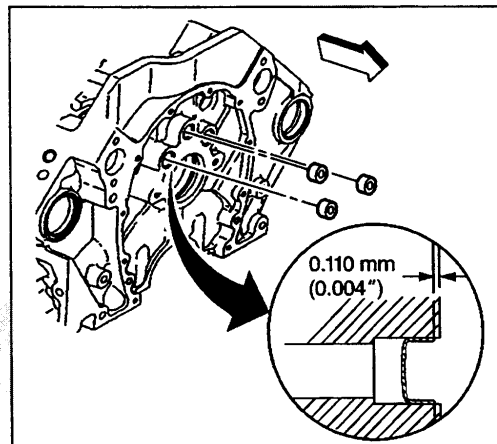
182854



182841



69847



182838

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Apply sealant GM P/N 12346004 or equivalent to the threads of the left side rear and left rear top engine oil gallery plugs.
6. Install the left side rear and left rear top oil engine gallery plugs.

Tighten

Tighten the left side rear and left rear top engine oil gallery plugs to 20 N·m (15 lb ft).

7. Apply sealant GM P/N 12346004 or equivalent to the threads of the square socket plugs (engine block oil gallery).
8. Install the rear oil gallery plugs.

Tighten

Tighten the square socket plugs to 20 N·m (15 lb ft).

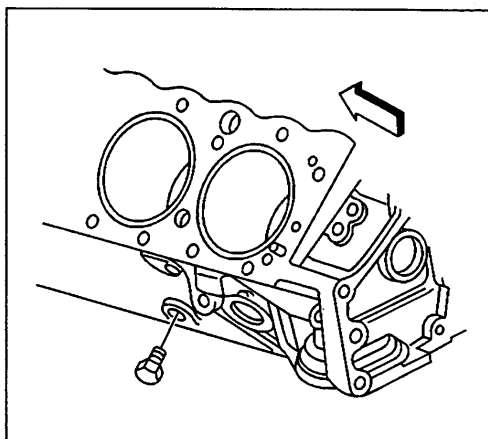
9. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW engine oil gallery plugs.
10. Install the NEW engine block oil gallery plugs.
A properly installed engine oil gallery plug must be installed below flush with the front face of the engine block.

11. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block coolant drain hole plug.

12. Install the engine block coolant drain hole plug.

Tighten

Tighten the engine block coolant drain hole plug to 20 N.m (15 lb ft).



69033

13. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine oil pressure sensor fitting.

Important: Do not loosen the oil pressure sensor fitting after the initial torque has been obtained.

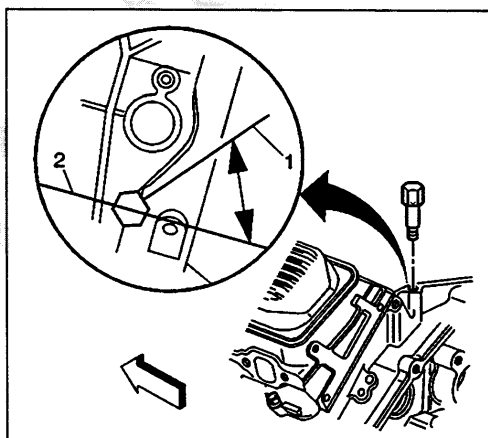
14. Install the engine oil pressure sensor fitting.

Tighten

Tighten the engine oil pressure sensor fitting to 15 N.m (11 lb ft).

Important: Do not rotate the engine oil pressure sensor fitting more than 359 degrees after the initial torque has been obtained.

15. Rotate the engine oil pressure sensor fitting clockwise to the proper position (1), 50 degrees from the centerline (2).



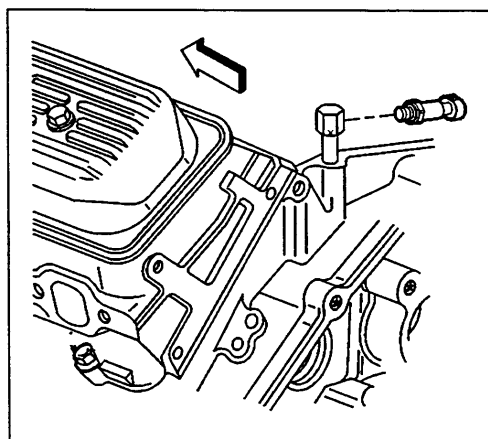
333659

16. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine oil pressure gauge sensor.

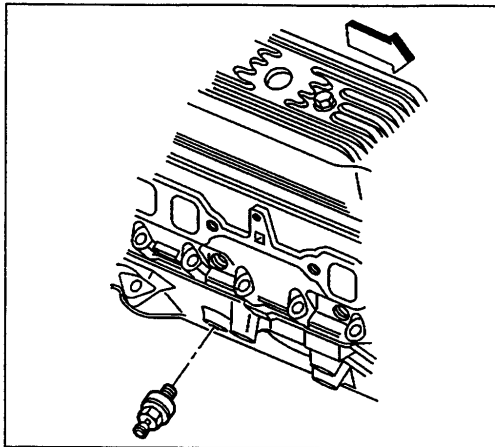
17. Install the engine oil pressure gauge sensor using the J 41712.

Tighten

Tighten the engine oil pressure gauge sensor to 30 N.m (22 lb ft).



333649

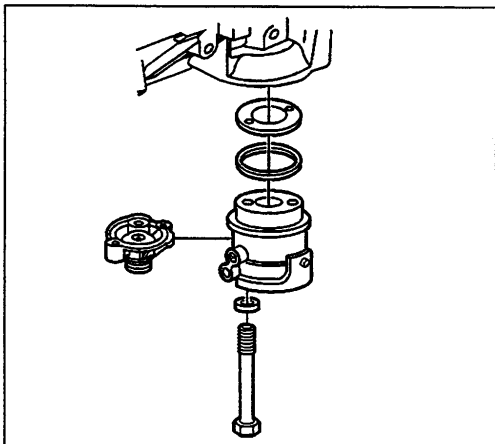


182837

18. Apply sealant GM P/N 12346004 or equivalent to the threads of the knock sensor.
19. Install the knock sensor.

Tighten

Tighten the knock sensor to 19 N·m (14 lb ft).



39122

SIE-ID = 69508

Oil Filter Adapter and Valve Assembly Installation

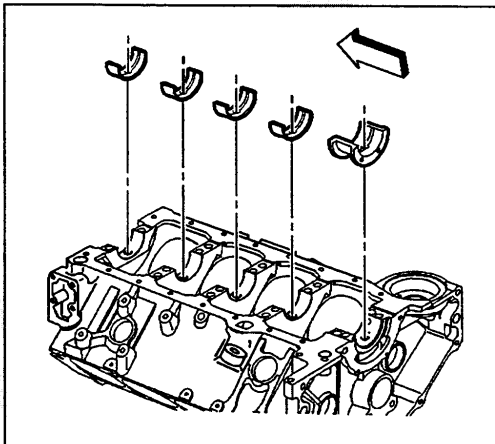
1. Apply clean engine oil GM P/N 12345610 or equivalent to the NEW oil filter adapter seal (O-ring) (if applicable).
2. Install the NEW oil filter adapter seal into the groove in the oil filter adapter (if applicable).
3. Install the NEW oil filter adapter gasket (if applicable) and the oil filter adapter.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the oil filter adapter flat washers (if applicable) and the oil filter adapter bolts.

Tighten

Tighten the oil filter adapter bolts to 25 N·m (18 lb ft).



317292

SIE-ID = 66853

Crankshaft and Bearings Installation

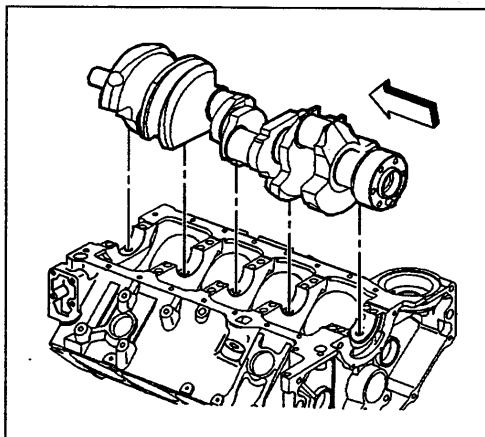
SIO-ID = 66901

Tools Required

J 36660 Electronic Torque Angle Meter

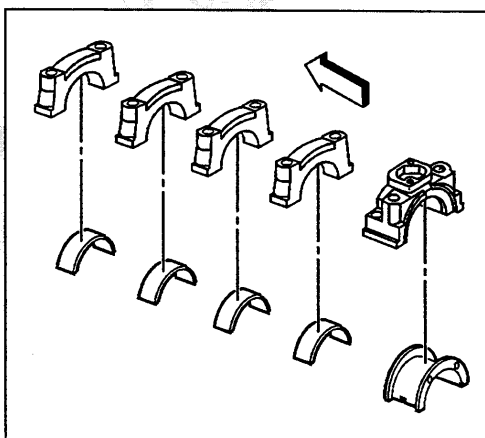
1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil GM P/N 12345610 or equivalent to the crankshaft bearings.

3. Apply clean engine oil GM P/N 12345610 or equivalent to the crankshaft bearing journals.
4. Install the crankshaft.



317351

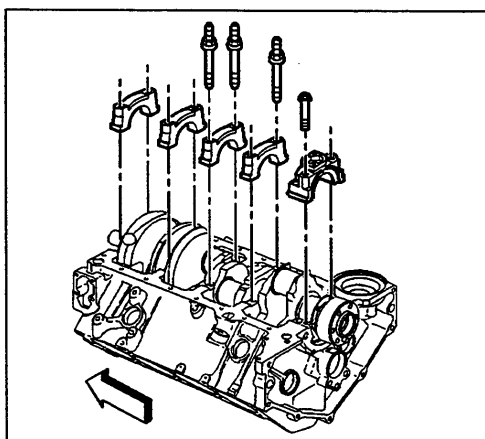
5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil GM P/N 12345610 or equivalent to the crankshaft bearings.



317295

Important: Be sure that the crankshaft bearing cap directional arrow point toward the front of the engine block and the crankshaft bearing cap is in the original location and position.

7. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
- Notice:** Refer to *Fastener Notice* in Cautions and Notices.
8. Install the crankshaft bearing cap bolts and studs.
 9. Thrust the crankshaft rearward in order to set and align the crankshaft thrust bearings and the crankshaft bearing caps.
 10. Thrust the crankshaft forward in order to align the rear faces of the crankshaft thrust bearings.
 11. Tighten the crankshaft bearing cap bolts and studs.



317268

Tighten

- 11.1. Tighten the crankshaft bearing cap bolts and studs on the first pass to 20 N·m (15 lb ft).
- 11.2. Tighten the crankshaft bearing cap bolts and studs (two bolt caps) on the final pass to 73 degrees using the *J 36660*.
- 11.3. Tighten the outboard bearing cap bolts (four bolt caps) on the final pass to 43 degrees using the *J 36660*.
- 11.4. Tighten the inboard bearing cap bolts and studs (four bolt caps) on the final pass to 73 degrees using the *J 36660*.

SIE-ID = 348923

Crankshaft Rear Oil Seal and Housing Installation**Tools Required***J 35621-B* Rear Main Seal Installer**Notice:** Refer to *Fastener Notice* in Cautions and Notices.

1. Install the crankshaft rear oil seal housing retainer stud.

Tighten

Tighten the crankshaft rear oil seal housing retainer stud to 6 N·m (53 lb in).

Important: Always use a NEW crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

2. Install the NEW crankshaft rear oil seal housing gasket and the crankshaft rear oil housing onto the crankshaft rear oil seal housing retainer stud.

3. Install the crankshaft rear oil seal housing nut and bolts.

Tighten

Tighten the crankshaft rear oil seal housing nut and bolts to 12 N·m (106 lb in).

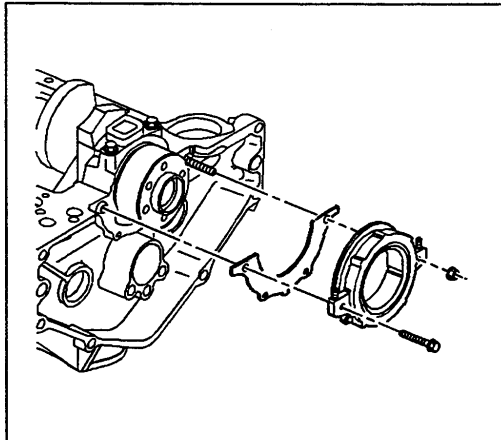
4. Apply a small amount (2 to 3 drops) of clean engine GM P/N 12345610 or equivalent oil to the bore of the crankshaft rear oil seal housing.
5. Inspect the outside diameter of the engine flywheel pilot flange for imperfections or rust. Minor imperfections and/or rust may be removed with a fine grade emery cloth.

6. Apply a small amount (2 to 3 drops) of clean engine GM P/N 12345610 or equivalent oil to the outside diameter of the engine flywheel pilot flange.

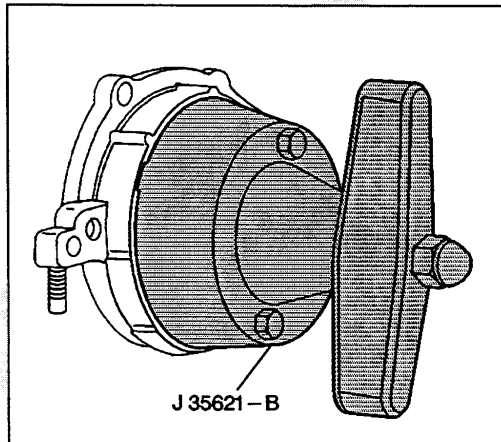
7. Apply a small amount (1 drop) of clean engine oil GM P/N 12345610 or equivalent to the outside diameter of the flywheel locator pin.

8. Apply a small amount of clean engine GM P/N 12345610 or equivalent oil to the crankshaft seal surface.

9. Inspect the *J 35621-B* flange for imperfections that may damage the crankshaft rear oil seal.



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Minor imperfections may be removed with a fine grade emery cloth.

Important: DO NOT allow oil or any other lubricants to contact the seal lip surface of the crankshaft rear oil seal.

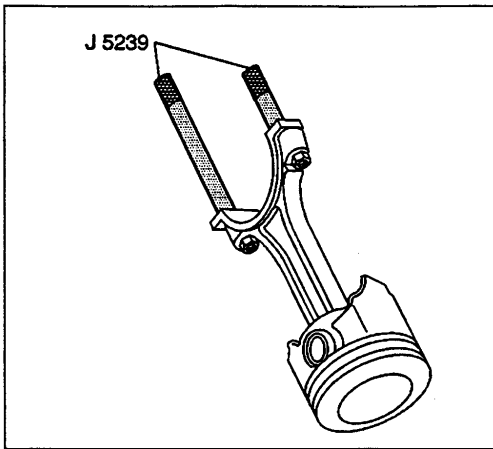
10. Remove the installation guide from the NEW crankshaft rear oil seal.
11. Apply a small amount (2 to 3 drops) of clean engine oil GM P/N 12345610 or equivalent to the outside diameter of the NEW crankshaft rear oil seal.
12. Install the NEW crankshaft rear oil seal onto the *J 35621-B*.
13. Install the *J 35621-B* onto the rear of the crankshaft and hand tighten the tool bolts until snug.

Notice: *S10-ID - 348112* Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

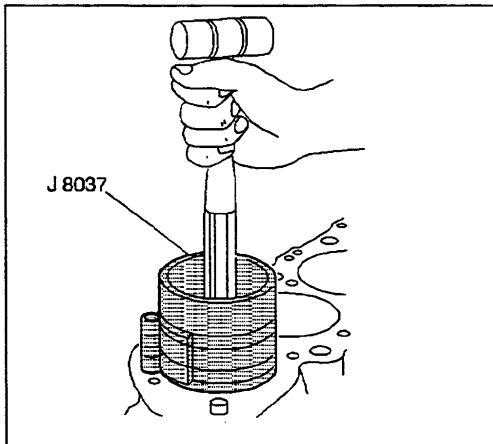
Important: A properly installed crankshaft rear oil seal will be near to flush and square to the crankshaft rear oil seal housing.

14. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 - 14.1. Turn the *J 35621-B* wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing.

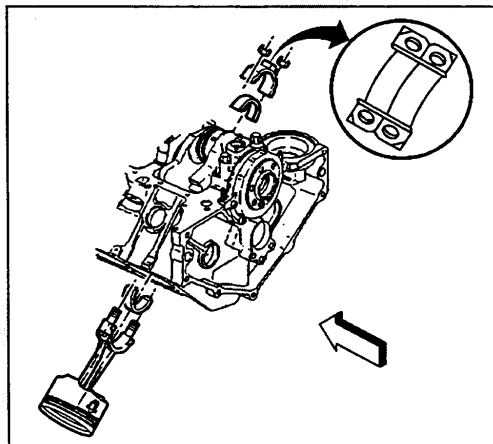
Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.
 - 14.2. Turn the *J 35621-B* wing nut counter clockwise to release the *J 35621-B* from the crankshaft rear oil seal.
15. Remove the *J 35621-B* from the crankshaft.
16. Wipe off any excess engine oil with a clean rag.



387765



5159



39124

SIE-ID = 222610

Piston, Connecting Rod, and Bearing Installation

SIO-ID = 222562

Tools Required

- J 5239 Connecting Rod Bolt Guide Set
- J 8037 Ring Compressor
- J 36660 Electronic Torque Angle Meter

1. Apply clean engine oil to the following components:
 - The piston
 - The piston rings
 - The cylinder bore
 - The connecting rod bearing surfaces
2. Install the J 5239 onto the connecting rod bolts.

3. Install the J 8037 onto the piston and compress the piston rings.

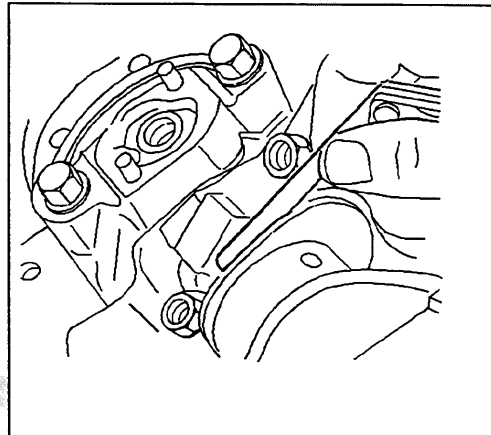
4. Install the piston and connecting rod assembly into the proper cylinder.
 - The mark on the top of the piston must face the front of the engine block.
 - When assembled, the flanges on the connecting rod and connecting rod cap should point to the front of the engine block on the left bank and point to the rear of the engine block on the right bank.
5. Use the J 8037 and the J 5239 and lightly tap the top of the piston with a wooden hammer handle.
 - Hold the J 8037 firmly against the engine block until all of the piston rings have entered the cylinder bore.
 - Use the J 5239 in order to guide the connecting rod onto the crankshaft journal.
6. Remove the J 5239 from the connecting rod bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the connecting rod cap and nuts.

Tighten

- 7.1. Tighten the nuts on the first pass evenly to 27 N.m (20 lb ft).
 - 7.2. Tighten the nuts on the final pass to 55 degrees using the *J 36660*.
8. Once the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly (parallel to the crankpin) in order to make sure that the connecting rods have the proper side clearance.
9. Use a feeler gauge or a dial indicator to measure the side clearance between the connecting rod caps. The connecting rod side clearance measurement should be 0.15–0.61 mm (0.006–0.024 in).



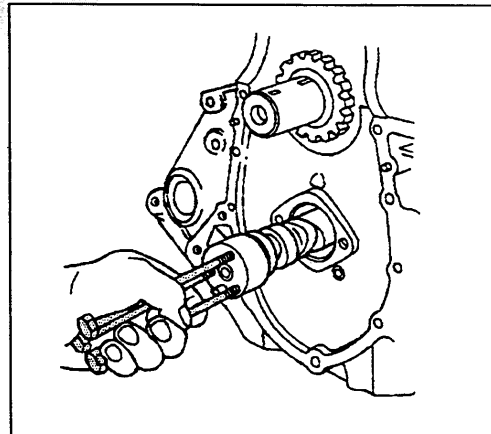
5163

SIE-ID = 66855

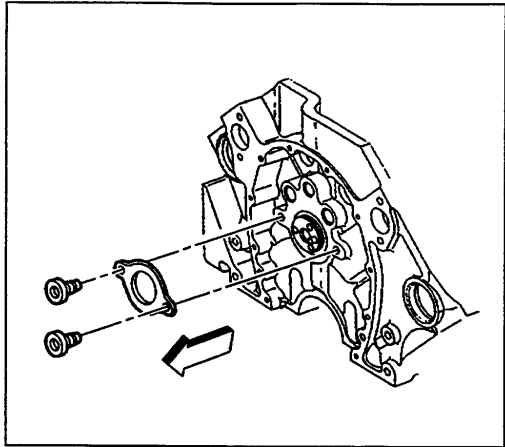
Camshaft Installation

Notice: SIO-ID = 13833 All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

1. Lubricate the following components with clean engine oil GM P/N 12345610 or equivalent or engine oil supplement GM P/N 1052367 or equivalent:
 - The engine camshaft lobes
 - The camshaft bearing journals
 - The camshaft bearings
2. Install the three 5/16–18 x 4.0 inch bolts in the engine camshaft bolt holes.
3. Install the engine camshaft using the bolts as a handle.
4. Remove the three bolts from the engine camshaft.



69013



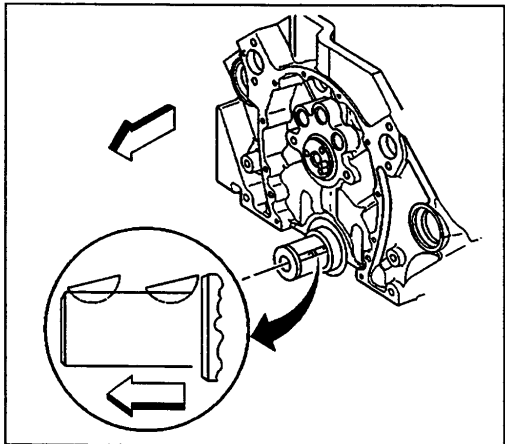
182836

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the camshaft retainer and bolts.

Tighten

Tighten the camshaft retainer bolts to 12 N.m (106 lb in).



182847

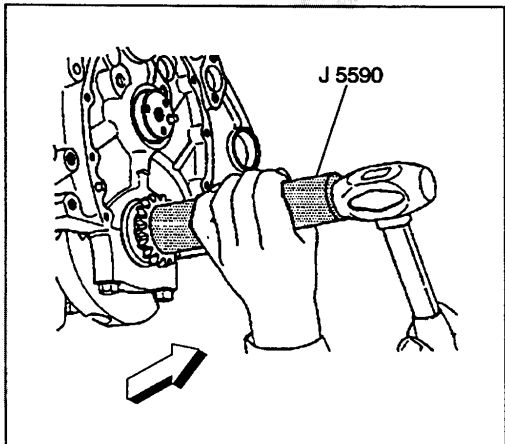
SIE-ID - 69464

Timing Chain and Sprockets Installation

Tools Required

J 5590 Installer

1. Install the woodruff key (crankshaft balancer) into the crankshaft keyway.



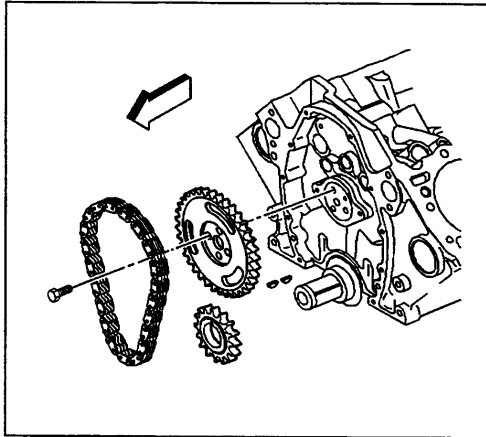
32066

2. Align the keyway of the crankshaft sprocket with the woodruff key (crankshaft balancer).

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

3. Use the J 5590 in order to install the crankshaft sprocket.
4. Rotate the crankshaft until the crankshaft sprocket alignment mark is in the 12 o'clock position.

5. Install the camshaft sprocket and the camshaft timing chain.
Install the camshaft sprocket with the alignment mark in the 6 o'clock position.



65453

Important: Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may dislodge the expansion cup plug (camshaft rear bearing hole) and/or damage the camshaft.

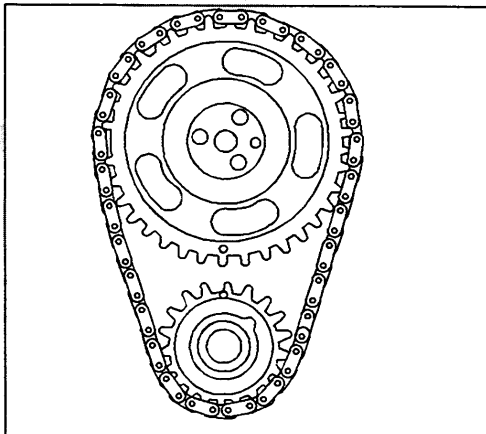
6. Rotate the camshaft until the camshaft and crankshaft sprocket alignment marks are in the proper position.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install camshaft sprocket bolts.

Tighten

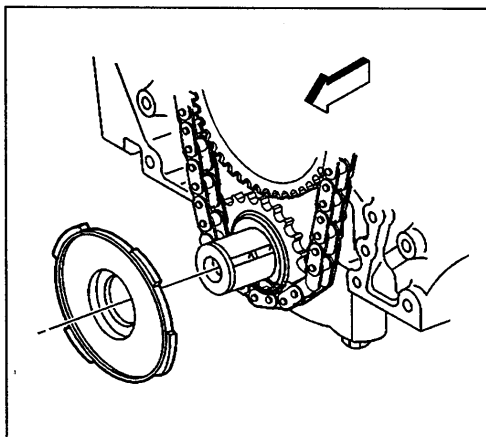
Tighten the camshaft sprocket bolts to 25 N.m (18 lb ft).



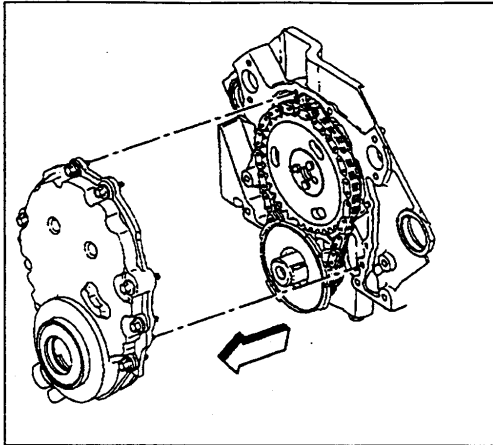
11503

Important: Align the keyway on the crankshaft position sensor reluctor ring with the woodruff key (crankshaft balancer) in the crankshaft, and install the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.

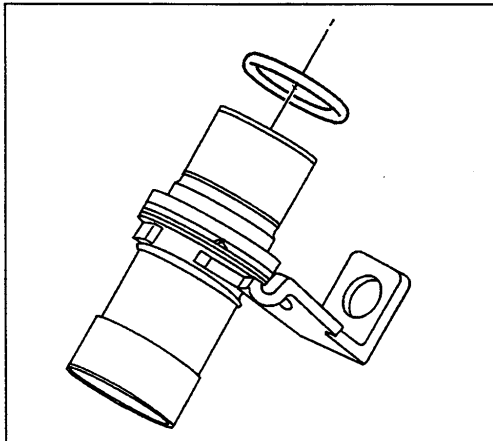
8. Install the crankshaft position sensor reluctor ring.
 - 8.1. Align the keyway on the crankshaft position sensor reluctor ring with the woodruff key (crankshaft balancer) in the crankshaft.
 - 8.2. Use the J 5590 in order to push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.



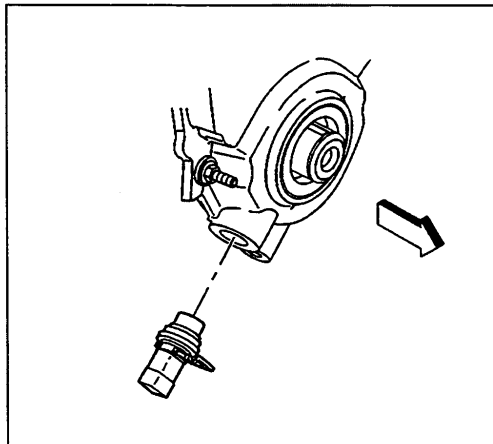
69450



69010



387759



10939

SIE-ID = 194773

Engine Front Cover Installation

Important: Do not reuse the composite type engine front cover and seal. Always install a NEW engine cover (includes a new seal).

1. Install the NEW engine front cover (includes a new seal).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the engine front cover bolts.

Tighten

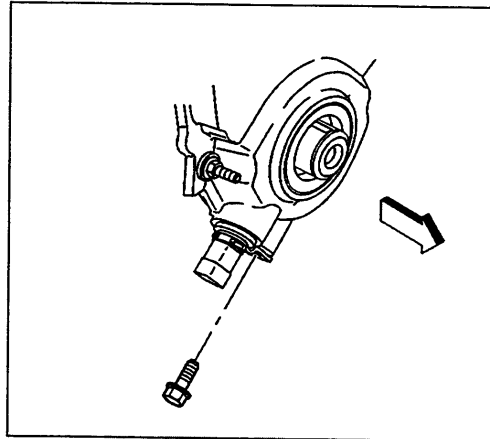
Tighten the engine front cover bolts to 12 N.m (106 lb in).

Important: DO NOT reuse the original crankshaft position sensor seal (O-ring). When installing the crankshaft position sensor be sure the crankshaft position sensor is fully seated and held stationary in the engine front cover crankshaft position sensor bore. A crankshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

3. Lubricate the NEW crankshaft position sensor seal (O-ring) with clean engine oil.
4. Install the NEW crankshaft position sensor seal (O-ring) onto the crankshaft position sensor.

5. Install the crankshaft position sensor.

6. Install the crankshaft position sensor bolt.
Tighten
Tighten the crankshaft position sensor bolt to 9 N·m (80 lb in).



10938

SIE-ID = 32349

Oil Level Indicator and Tube Installation

1. Apply sealant GM P/N 12346004 or equivalent around the oil level indicator tube 13 mm (0.5 in) below the tube bead.
2. Install the oil level indicator tube into the engine block. Rotate the oil level indicator tube into position.

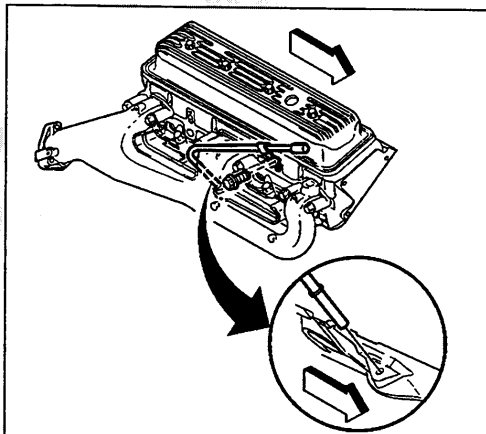
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil level indicator tube bolt.

Tighten

Tighten the oil level indicator tube bolt to 12 N·m (106 lb in).

4. Install the oil level indicator into the oil level indicator tube.

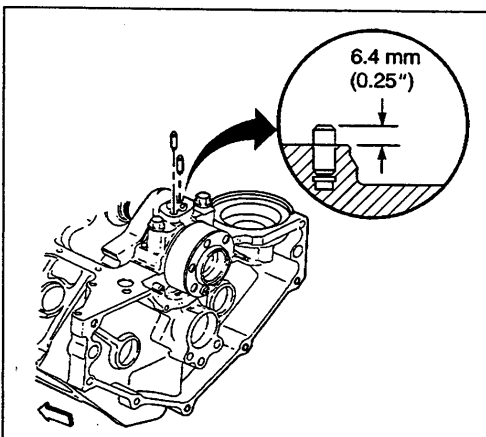


182831

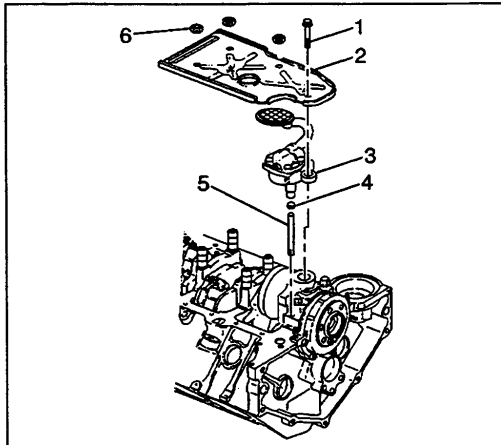
SIE-ID = 194869

Oil Pump, Pump Screen and Deflector Installation

1. Inspect for properly installed pins (oil pump locator).



182852



11438

Important: Do not reuse the oil pump driveshaft retainer (4).

During assembly, install a NEW oil pump driveshaft retainer.

2. Assemble the oil pump (3), oil pump driveshaft (5), and a NEW oil pump driveshaft retainer (4).
3. Install the oil pump (3).
Position the oil pump onto the pins.
4. Install the bolt (1) attaching the oil pump to the rear crankshaft bearing cap.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the crankshaft oil deflector (2) and nuts (6).

Tighten

- Tighten the oil pump bolt to 90 N.m (66 lb ft).
- Tighten the crankshaft oil deflector nuts to 40 N.m (29 lb ft).

SIE-ID - 66859

Oil Pan Installation

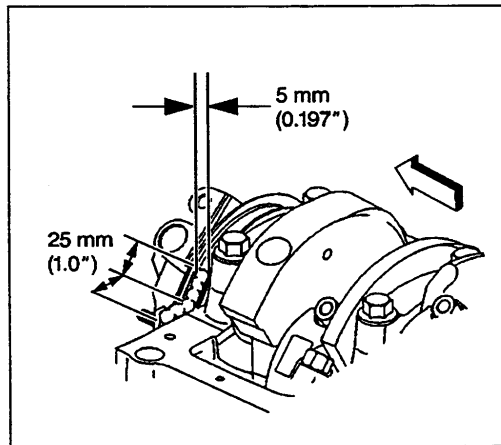
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the oil pan studs into the engine block.

Tighten

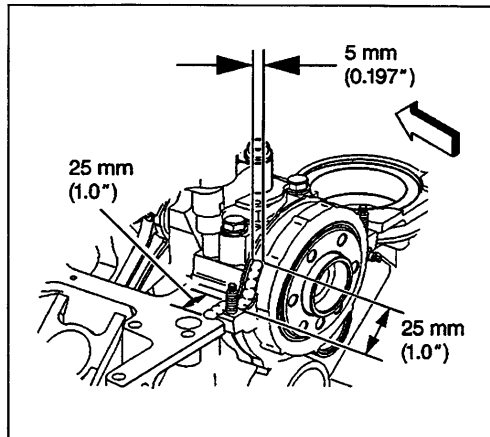
Tighten the oil pan studs to 6 N.m (53 lb in).

2. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 or equivalent, to the engine front cover to engine block junction at the oil pan sealing surfaces.



317310

3. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 or equivalent, to the crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.



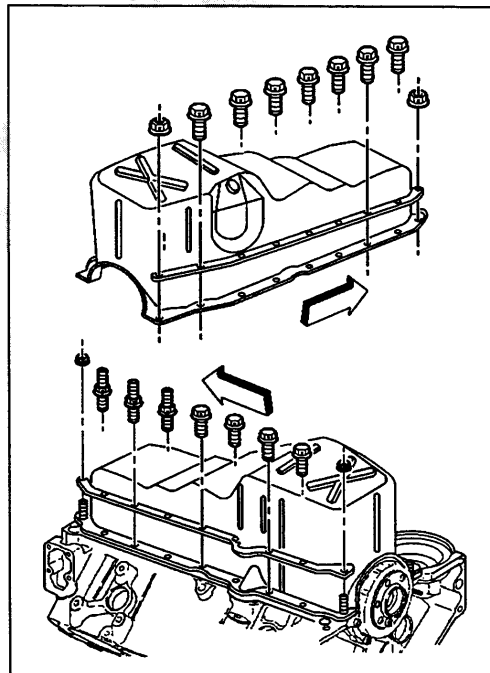
317313

Important: Always install a NEW oil pan gasket. The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

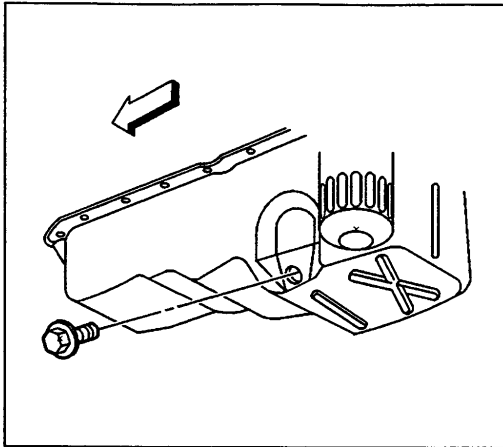
4. Install the NEW oil pan gasket.
5. Install the oil pan.
Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.
6. Install the oil pan reinforcements.
7. Install the nuts and the bolts.

Tighten

- 7.1. Tighten the oil pan bolts to 12 N.m (106 lb in).
- 7.2. Tighten the oil pan nuts to 25 N.m (18 lb ft).



182851

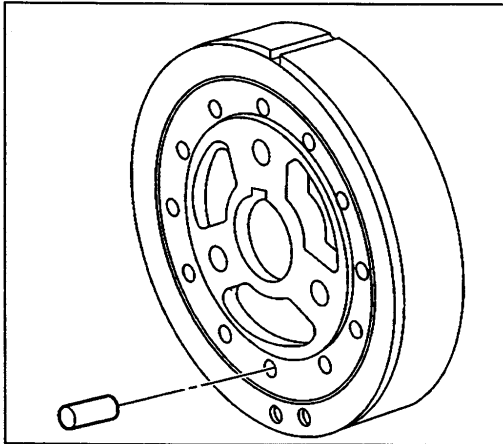


182850

8. Install a NEW oil pan drain plug seal (O-ring) onto the oil pan drain plug.
9. Install the oil pan drain plug into the oil pan.

Tighten

Tighten the oil pan drain plug to 25 N·m (18 lb ft).



182849

SIE-ID - 66868

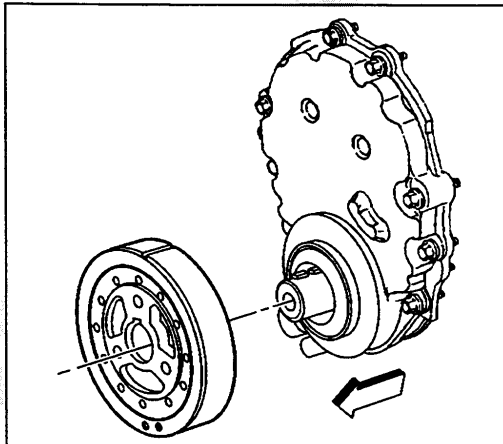
Crankshaft Balancer Installation

SIO-ID - 67079

Tools Required

J 23523-F Balancer Remover and Installer

1. Look to ensure that the front groove pin (crankshaft balancer) is installed in the proper location (if applicable).

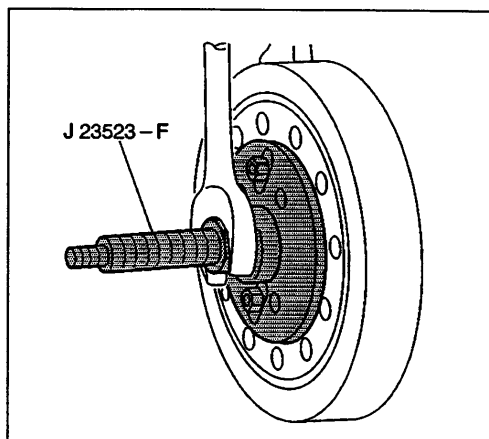


182832

Notice: SIO-ID - 16580 The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

2. Apply a small amount of adhesive GM P/N 12346141 or equivalent onto the crankshaft balancer keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
3. Install the crankshaft balancer onto the end of the crankshaft.
Align the keyway of the crankshaft balancer with the woodruff key (crankshaft balancer).

4. Use the *J 23523-F* in order to press the crankshaft balancer onto the crankshaft.
 - 4.1. Install the *J 23523-F* into the front of the crankshaft.
 - 4.2. Rotate the *J 23523-F* nut until the nut, the washer, and the bearing are firmly against the crankshaft balancer.
 - 4.3. Use one wrench to hold the *J 23523-F* forcing screw.
 - 4.4. Use a second wrench and rotate the *J 23523-F* nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.
 - 4.5. Remove the *J 23523-F*.



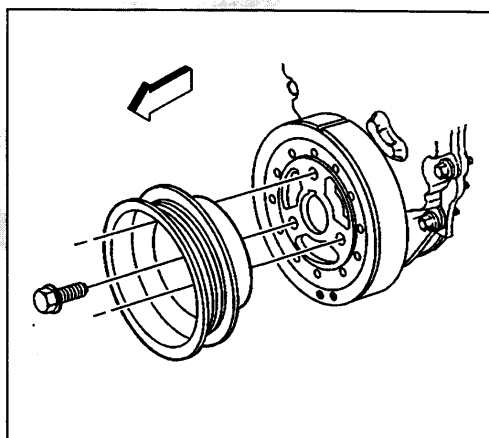
4065

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the crankshaft pulley and bolts.

Tighten

Tighten the crankshaft pulley bolts to 58 N·m (43 lb ft).

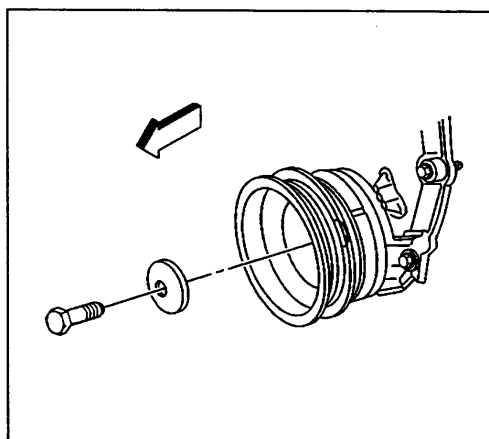


188055

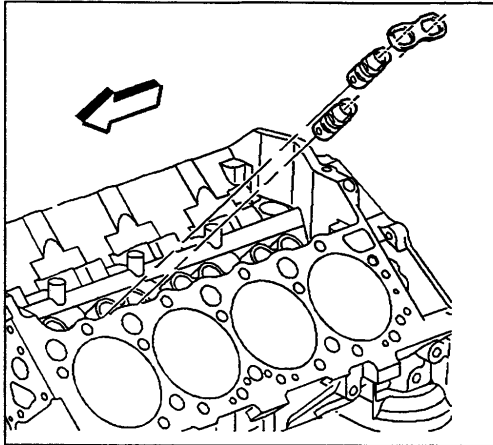
6. Install the crankshaft balancer washer and the bolt.

Tighten

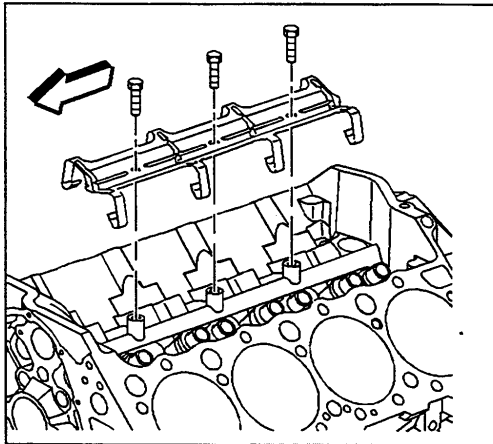
Tighten the crankshaft balancer bolt to 95 N·m (70 lb ft).



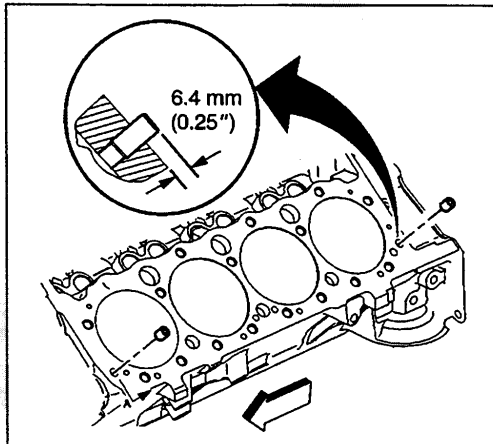
173172



11509



11508



182846

SIE-ID = 69825

Valve Lifter Installation

SIO-ID = 68951

1. Apply lubricant GM P/N 12345501 or equivalent to the valve lifter rollers.

Important: If reusing the valve lifters, install the valve lifters in the original positions.

2. Install the valve lifters.

3. Install the valve lifter guides.
4. Install the valve lifter guide retainer.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the valve lifter guide retainer bolts.

Tighten

Tighten the valve lifter guide retainer bolts to 25 N.m (18 lb ft).

SIE-ID = 66861

Cylinder Head Installation (Left)

SIO-ID = 66903

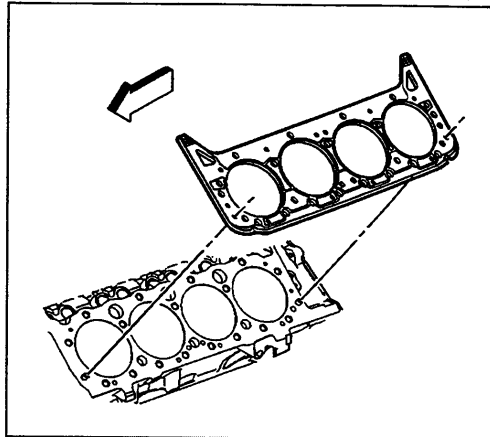
Tools Required

J 36660 Electronic Torque Angle Meter

1. Clean the cylinder gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locator) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder head.

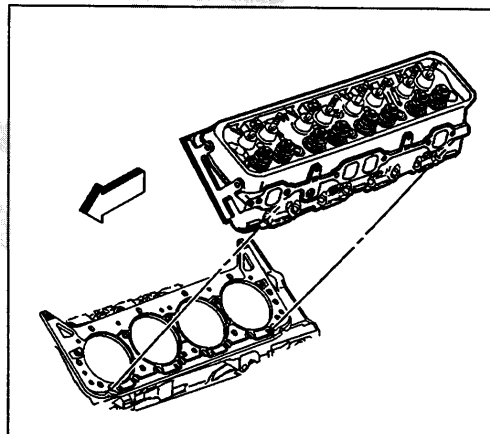
Important: Do not use any type sealer on the cylinder head gasket (unless specified).

4. Place the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).



317233

5. Install the cylinder head to the engine block.
Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

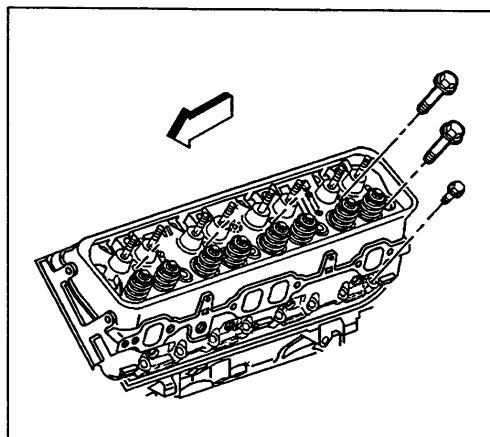


317227

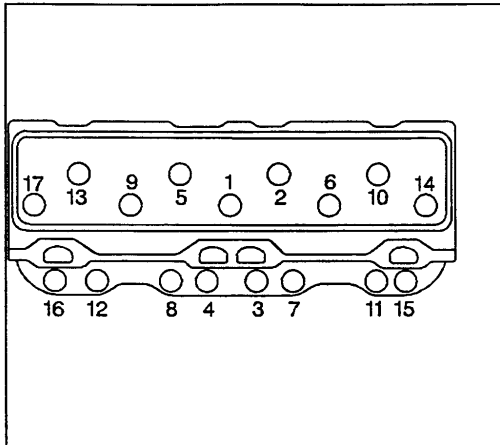
6. Apply sealant GM P/N 12346004 or equivalent to the threads of the cylinder head bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

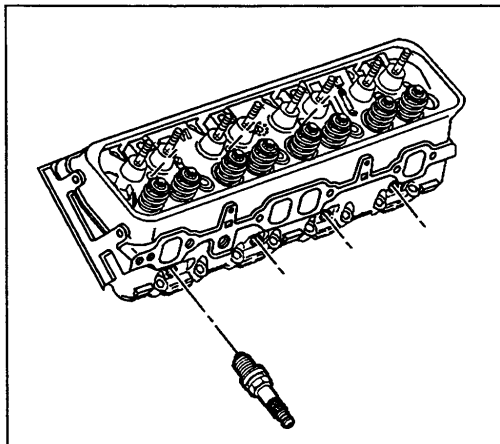
7. Install the cylinder head bolts.



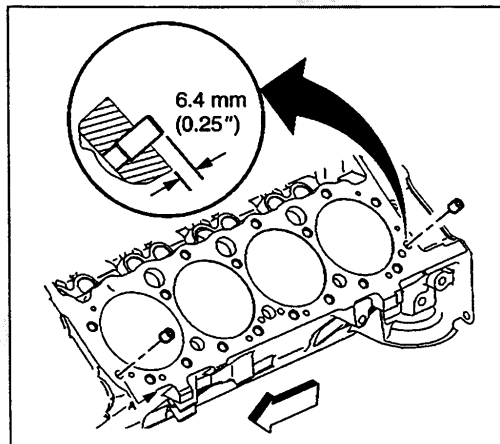
317217



11523



317307



182846

8. Tighten the cylinder head bolts in sequence on the first pass.

Tighten

Tighten the bolts in sequence on the first pass to 30 N·m (22 lb ft).

9. Use the *J 36660* in order to tighten the cylinder head bolts in sequence on the final pass.

Tighten

- Tighten the long bolts (1, 2, 5, 6, 9, 10, and 13) on the final pass in sequence to 75 degrees.
- Tighten the medium bolts (14 and 17) on the final pass in sequence to 65 degrees.
- Tighten the short bolts (3, 4, 7, 8, 11, 12, 15, and 16) on the final pass in sequence to 55 degrees.

10. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

Specification

Spark plug gap to 1.52 mm (0.060 in).

11. Install the NEW spark plugs.

Tighten

- Tighten the spark plugs for a USED cylinder head to 15 N·m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N·m (22 lb ft).

SIE-ID - 194890

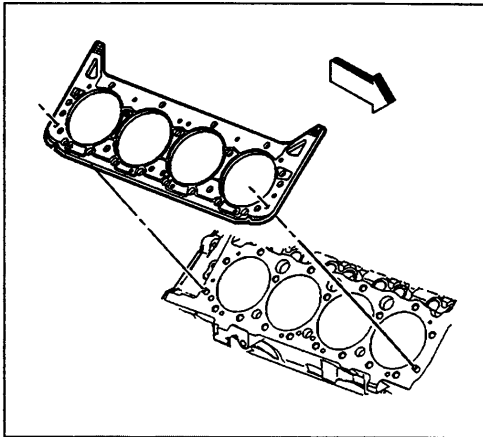
Cylinder Head Installation (Right)**Tools Required**

J 36660 Electronic Torque Angle Meter

1. Clean the cylinder gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locator) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder head.

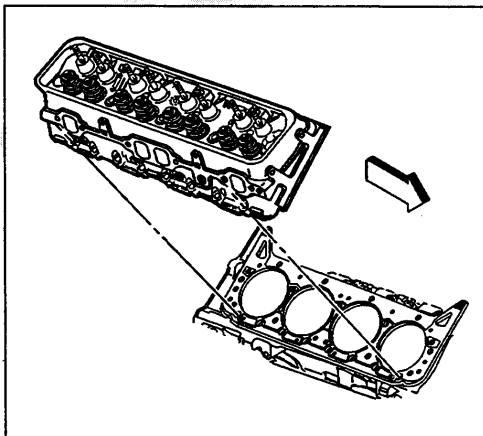
Important: Do not use any type sealer on the cylinder head gasket (unless specified).

4. Place the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).



317255

5. Install the cylinder head to the engine block. Guide the cylinder head carefully into place over the dowel pins and the head gasket.

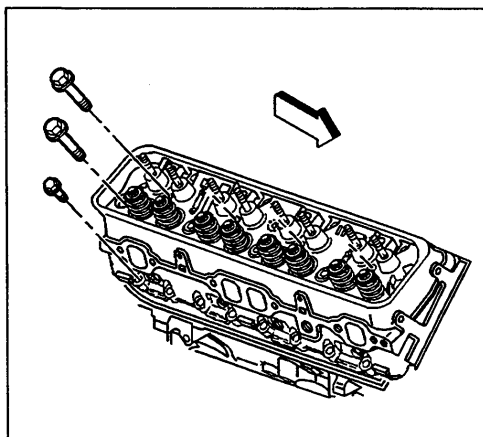


317246

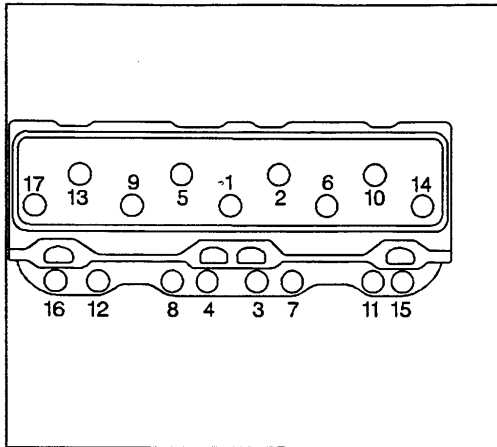
6. Apply sealant GM P/N 12346004 or equivalent to the threads of the cylinder head bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

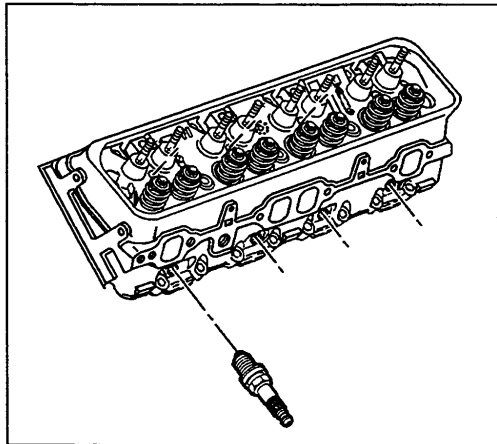
7. Install the cylinder head bolts.



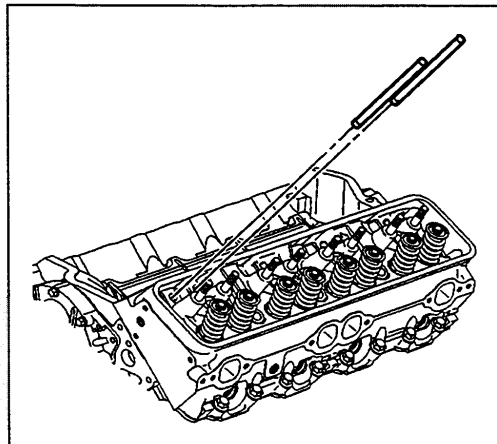
317239



11523



317307



22766

8. Tighten the cylinder head bolts in sequence on the first pass.

Tighten

Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the *J 36660* in order to tighten the cylinder head bolts in sequence on the second pass.

Tighten

- Tighten the long bolts (1, 2, 5, 6, 9, 10, and 13) on the second pass in sequence to 75 degrees.
- Tighten the medium bolts (14 and 17) on the second pass in sequence to 65 degrees.
- Tighten the short bolts (3, 4, 7, 8, 11, 12, 15, and 16) on the second pass in sequence to 55 degrees.

10. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

Specifications

Spark plug gap to 1.52 mm (0.060 in).

11. Install the NEW spark plugs.

Tighten

- Tighten the spark plugs for a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

SIE-ID = 194762

Valve Rocker Arm and Push Rod Installation

Important: Be sure to keep parts in order. Parts must be put back from where they were removed.

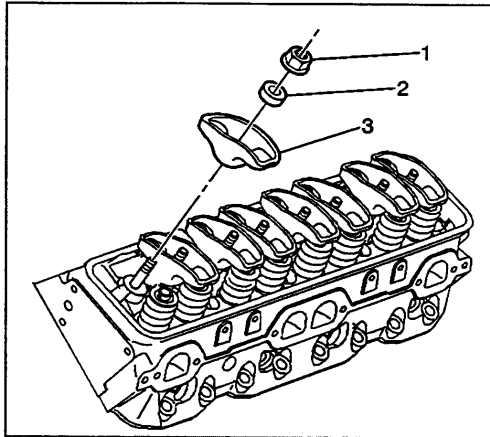
1. Apply prelube GM P/N 12345501 or equivalent to the valve rocker arm and the valve rocker arm ball bearing surfaces.

Important: Be sure that the valve pushrods seat in the valve lifter sockets.

2. Install the valve pushrods.

3. Install the following parts:

- 3.1. The valve rocker arm nuts (1)
- 3.2. The valve rocker arm balls (2)
- 3.3. The valve rocker arms (3)

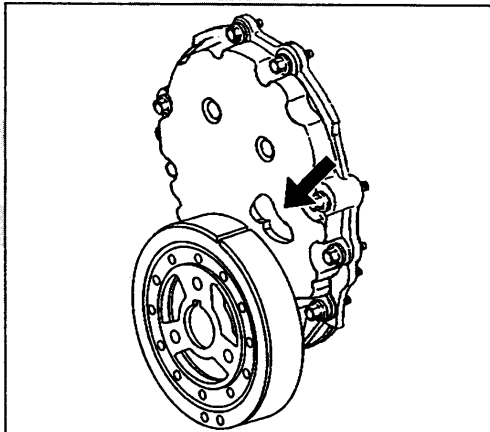


182835

SIE-ID = 194734

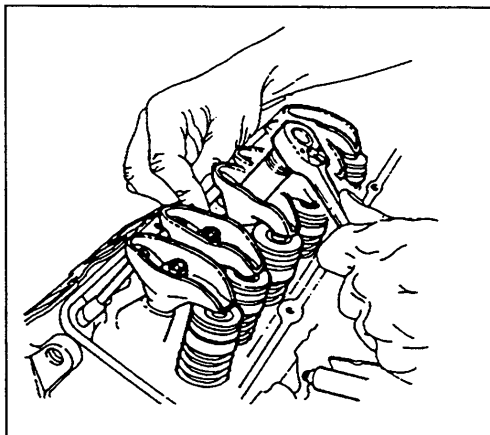
Valve Lash Adjustment

- 1. Turn the valve rocker arm nuts clockwise until all of the valve lash is removed.
- 2. Turn the crankshaft clockwise until the alignment mark on the crankshaft balancer is aligned with the notch in the engine front cover tab.
- 3. Look at the number 1 cylinder valves as the crankshaft balancer alignment mark approaches the notch in the engine front cover tab. If a valve moves as the alignment mark moves into position, the engine is in the number 6 firing position. If this happens, turn the crankshaft clockwise one revolution in order to reach the number 1 cylinder firing position.

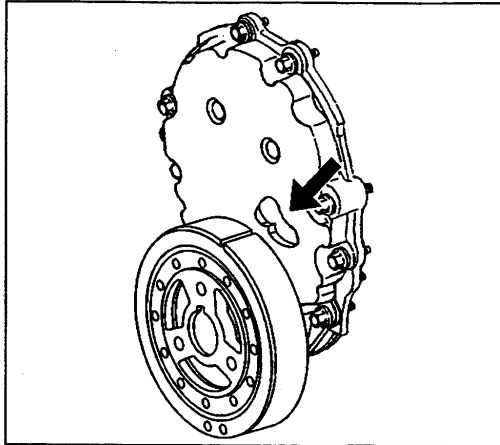


195336

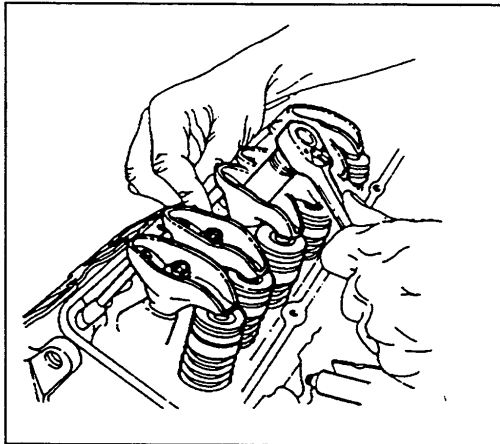
- 4. With the engine in the number 1 firing position, adjust the exhaust valves for cylinders number 1, 3, 4, and 8 and the intake valves for cylinders number 1, 2, 5, and 7.
 - 4.1. Turn the valve rocker arm nut counter clockwise until the valve lash is felt in the valve pushrod.
 - 4.2. Turn the valve rocker arm nut clockwise until all the valve lash is removed (zero valve lash).
Zero valve lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more up and down movement of the valve push rod.
 - 4.3. When all the valve lash is removed, then turn the valve rocker arm nut clockwise 1 additional turn (360 degrees).



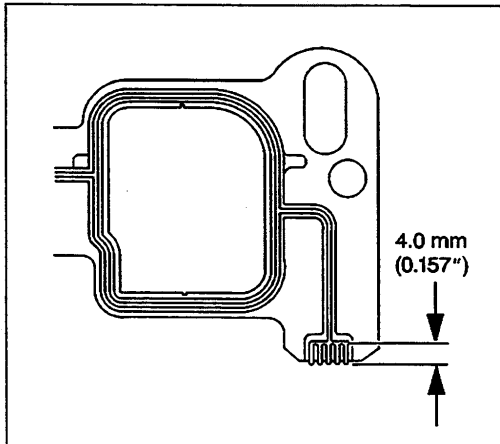
22759



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22759



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5. Turn the crankshaft clockwise 1 revolution until the alignment mark on the crankshaft balancer is aligned with the notch in the engine front cover tab.

6. With the engine in the number 6 firing position, adjust the exhaust valves for cylinders number 2, 5, 6, and 7 and the intake valves for cylinders number 3, 4, 6, and 8.

- 6.1. Turn the valve rocker arm nut counter clockwise until the valve lash is felt in the valve pushrod.

- 6.2. Turn the valve rocker arm nut clockwise until all the valve lash is removed (zero valve lash).

Zero valve lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more up and down movement of the valve push rod.

- 6.3. When all the valve lash is removed, then turn the valve rocker arm nut clockwise 1 additional turn (360 degrees).

SIE-ID = 66866

Intake Manifold Installation

SIO-ID = 67832

Notice: SIO-ID = 16302 Applying excessive amounts of sealant may prohibit the intake gasket from sealing properly.

Important: The lower intake manifold must be installed and the fasteners tightened while the adhesive is still wet to the touch.

1. Apply a 4.0 mm (0.157 in) patch of adhesive GM P/N 12346141 or equivalent to the cylinder head side of the lower intake manifold gasket at each end.
2. Install the lower intake manifold gasket onto the cylinder head.

Use the gasket locator pins in order to properly seat the lower intake manifold gasket onto the cylinder head.

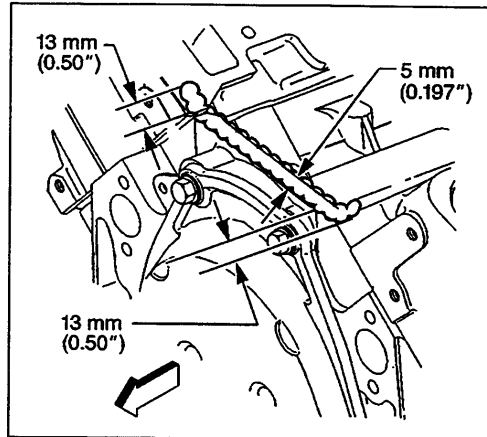
Engine

Engine Mechanical - 5.0L, 5.7L 6-235

Notice: SIO-ID - 41431 Care must be used to apply the correct amount of sealant onto the gaskets. Applying excessive amounts of sealant may prohibit the intake gaskets from sealing properly.

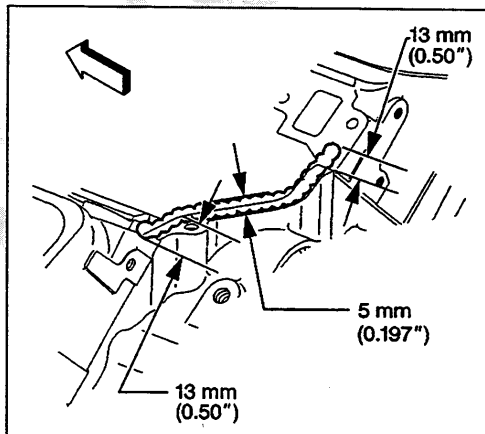
Important: All sealing surfaces must be clean, free of oil, dirt, or any other foreign material.

3. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the front top of the engine block.
4. Extend the adhesive bead 13 mm (0.50 in) onto the each lower intake manifold gasket.



26744

5. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the rear top of the engine block.
6. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

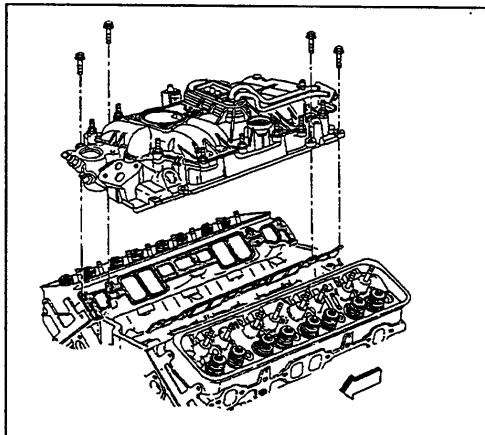


26743

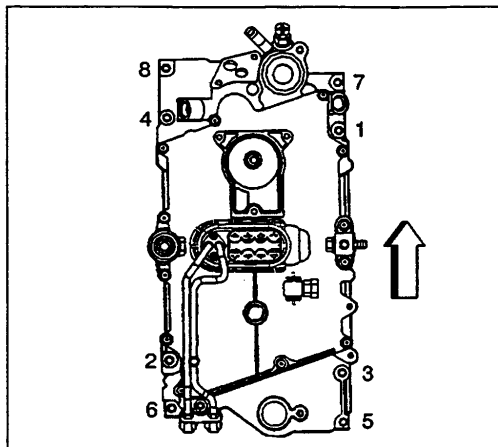
7. Install the lower intake manifold onto the engine block and the cylinder heads.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

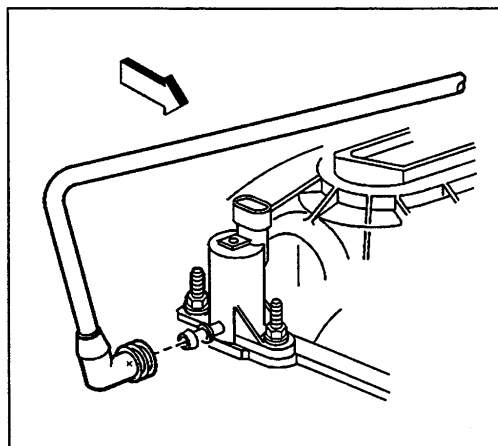
8. Apply threadlock GM P/N 12345382 or equivalent to the threads of the lower intake manifold bolts.



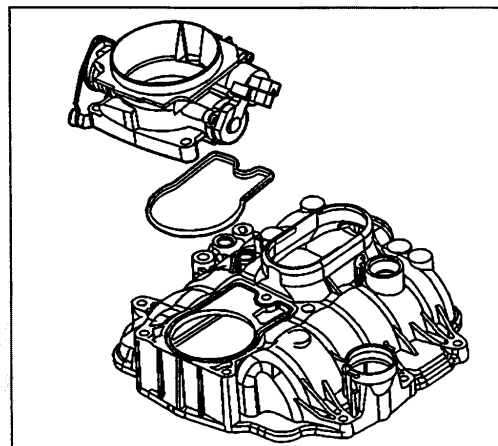
66456



31698



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12853

Notice: SIO-ID = 382467 Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

9. Install the lower intake manifold bolts.

Tighten

- 9.1. Tighten the bolts on the first pass in sequence (1–8) to 3 N.m (27 lb in).
- 9.2. Tighten the bolts on the second pass in sequence (1–8) to 12 N.m (106 lb in).
- 9.3. Tighten the bolts on the final pass in sequence (1–8) to 15 N.m (11 lb ft).

10. Connect the evaporative emission (EVAP) canister purge solenoid valve harness.

11. Install the vacuum hose.

SIE-ID = 194662

Throttle Body Installation

1. Install a NEW throttle body gasket into the groove of the upper intake manifold.
2. Install the throttle body onto the upper intake manifold.

Engine

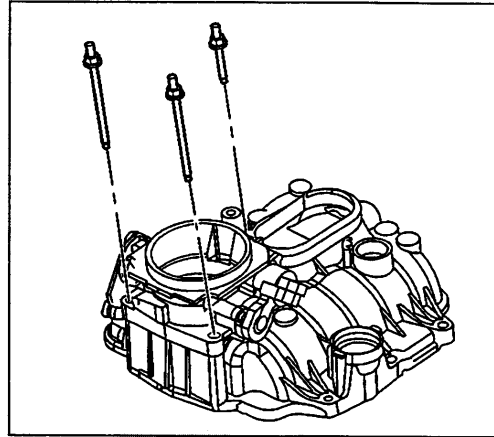
Engine Mechanical - 5.0L, 5.7L 6-237

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the throttle body attaching studs.

Tighten

Tighten the throttle body attaching studs to 9 N·m (80 lb in).

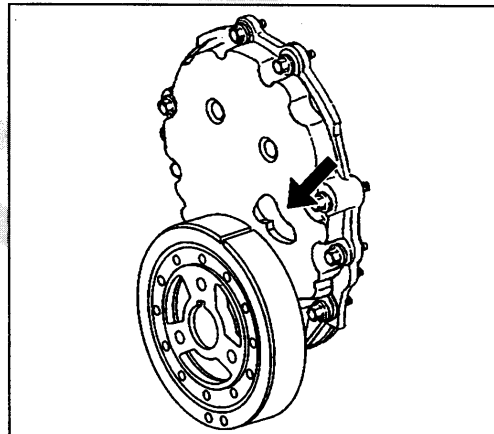


12852

SIE-ID = 69509

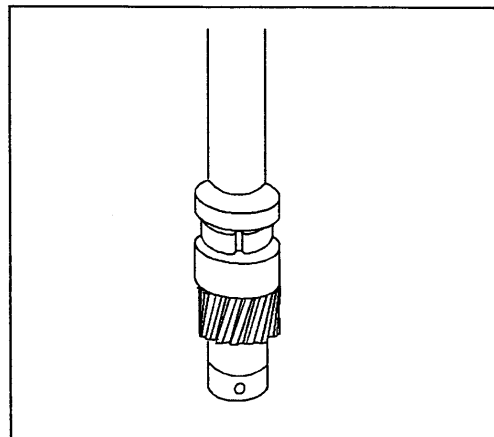
Distributor Installation

1. Bring cylinder number one piston to Top Dead Center (TDC) of compression stroke.
2. Remove the distributor cap bolts and discard.
3. Remove the distributor cap.

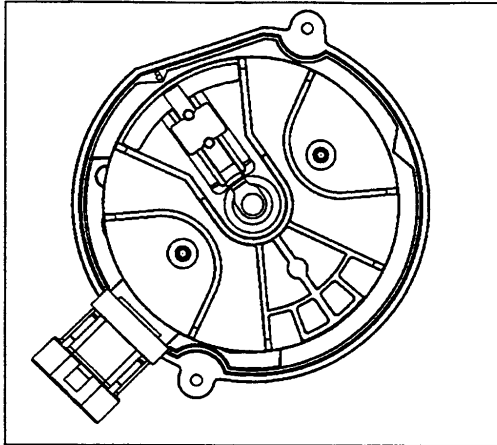


195336

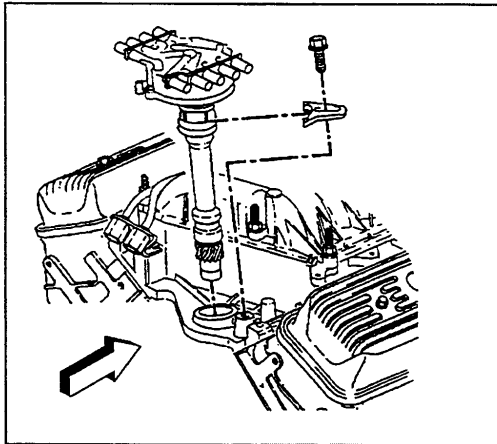
4. Align the indent hole on the driven gear with the paint mark on the distributor housing.



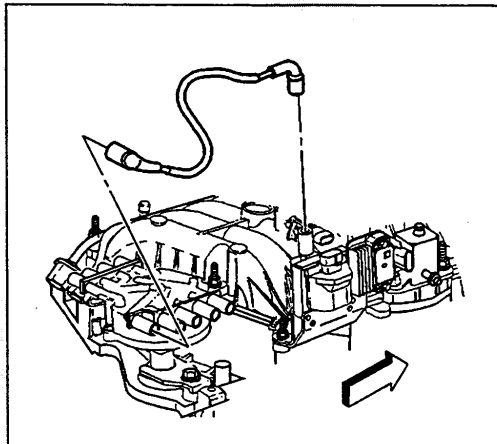
43756



68505



69303



341359

5. Ensure that the distributor rotor segment points to the cap hold area.
6. Align the slotted tang in the oil pump driveshaft with the distributor driveshaft. Rotate the oil pump driveshaft with a screwdriver if necessary.
7. Install the distributor and NEW distributor gasket. The flat in the distributor housing must point toward the front of the engine.
8. Once the distributor is fully seated, align the distributor rotor segment with the number 8 pointer that is cast into the distributor base.
9. If the distributor rotor segment does not come within a few degrees of the number 8 pointer, the gear mesh between the distributor and camshaft may be off a tooth or more. Repeat the procedure in order to achieve proper alignment.

10. Install the distributor cap.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

11. Install the NEW distributor cap mounting bolts. Do not overtighten the NEW bolts as the distributor housing boss may strip.

Tighten

Tighten the distributor cap bolts to 5 N·m (44 lb in).

12. Install the distributor clamp and bolt.

Tighten

Tighten the distributor clamp bolt to 25 N·m (18 lb ft).

13. Install the ignition coil wire harness.

SIE-ID - 66864

Valve Rocker Arm Cover Installation (Left)

SIO-ID - 66906

Important: Always install a NEW valve rocker arm cover gasket.

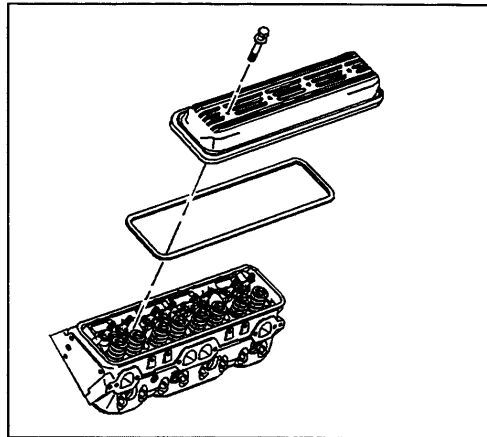
1. Install the NEW valve rocker arm cover gasket.
2. Install the valve rocker arm cover.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the valve rocker arm cover washers and bolts.

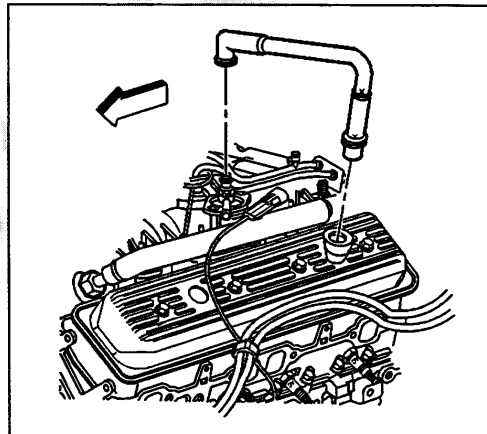
Tighten

Tighten the bolts to 12 N·m (106 lb in).



39119

4. Install the PCV valve hose assembly.



317197

SIE-ID - 194900

Valve Rocker Arm Cover Installation (Right)

Important: Always install a NEW valve rocker arm cover gasket.

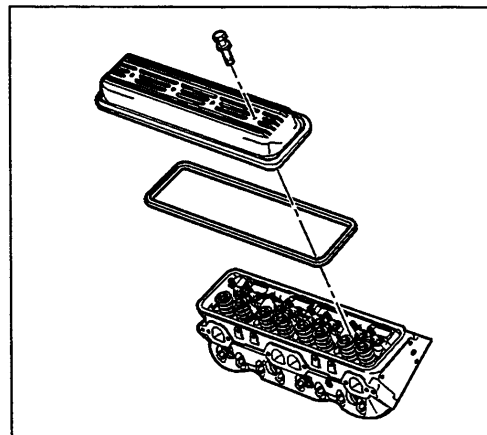
1. Install the NEW valve rocker arm cover gasket.
2. Install the valve rocker arm cover.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

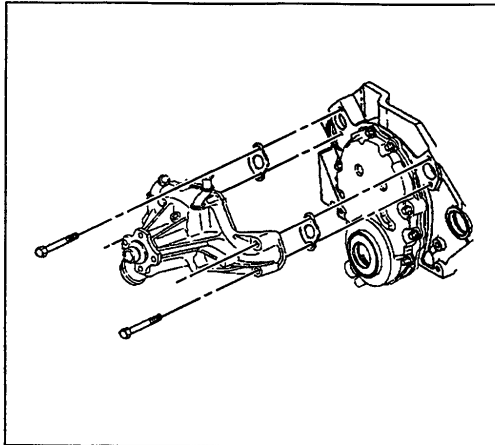
3. Install the valve rocker arm cover washers and bolts.

Tighten

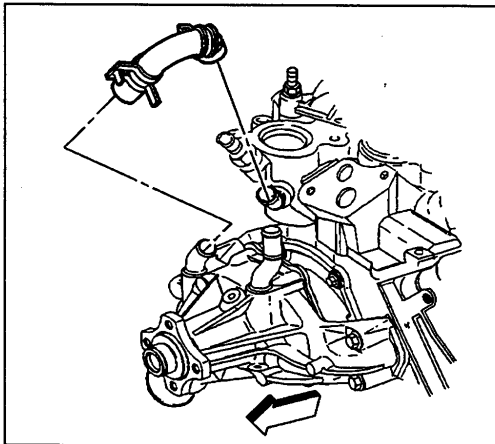
Tighten the bolts to 12 N·m (106 lb in).



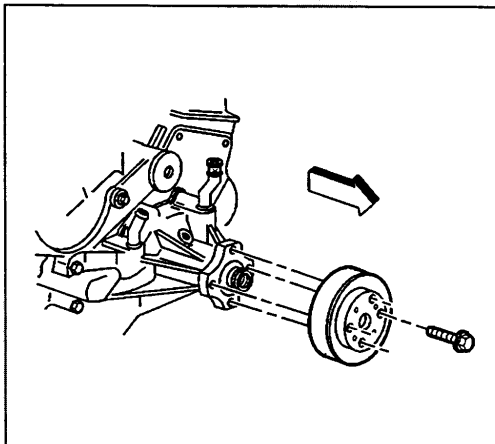
182833



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317191

SIE-ID - 69040

Water Pump Installation

1. Apply sealant GM P/N 12346004 or equivalent to the threads of the water pump bolts.
2. Install NEW water pump gaskets.
3. Install the water pump.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the water pump bolts.

Tighten

Tighten the water pump bolts to 45 N.m (33 lb ft).

Important: After final assembly, the water pump inlet hose clamp tangs (water pump end) must point forward and the upper tang should be level with the outside diameter of the water pump inlet hose.

5. Install the water pump inlet hose and the water pump inlet hose clamps.

6. Install the fan and water pump pulley and bolts.

Tighten

Tighten the fan and water pump pulley bolts to 25 N.m (18 lb ft).

SIE-ID - 67320

Exhaust Manifold Installation (Left)

SIO-ID - 66909

1. Install the NEW exhaust manifold gasket.
2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. Apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the exhaust manifold bolts.

Tighten

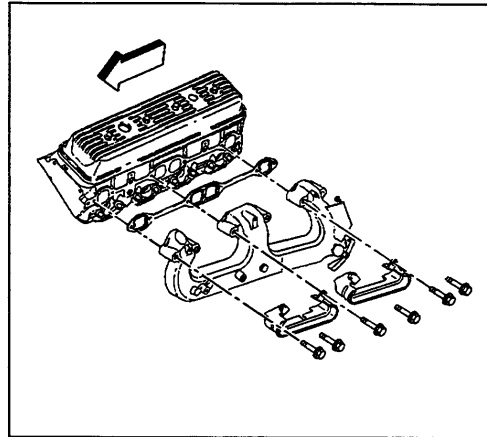
- 5.1. Tighten the exhaust manifold bolts on the first pass to 15 N.m (11 lb ft).
- 5.2. Tighten the exhaust manifold bolts on the final pass to 30 N.m (22 lb ft).

6. Install the spark plug wire supports and bolts.

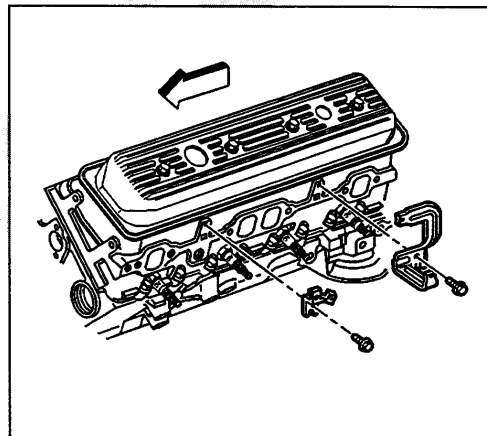
Tighten

Tighten the bolts to 12 N.m (106 lb in).

7. Install the spark plug wires onto the spark plugs.



64925



317185

SIE-ID - 66869

Exhaust Manifold Installation (Right)

SIO-ID - 66908

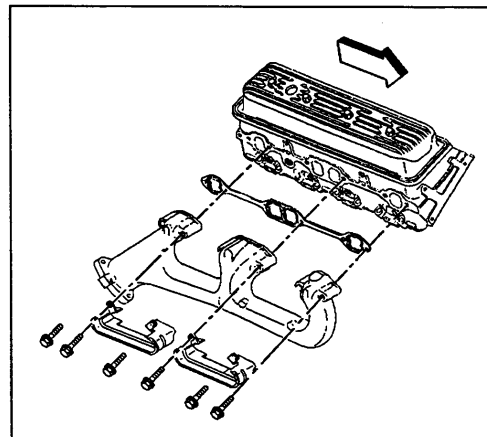
1. Install the NEW exhaust manifold gasket.
2. Install the exhaust manifold.
3. Install the spark plug heat shields.
4. Apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

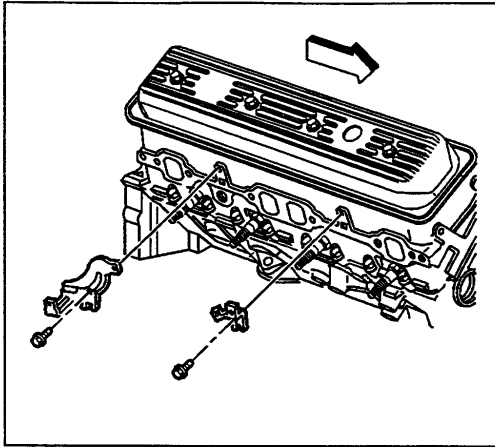
5. Install the exhaust manifold bolts.

Tighten

- 5.1. Tighten the exhaust manifold bolts on the first pass to 15 N.m (11 lb ft).
- 5.2. Tighten the exhaust manifold bolts on the final pass to 30 N.m (22 lb ft).

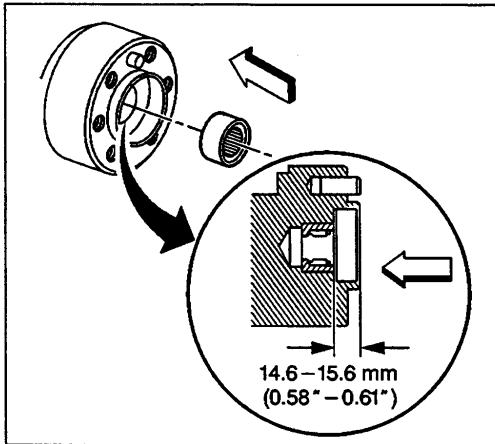


69032



317179

6. Install the spark plug wire supports and bolts.
Tighten
Tighten the bolts to 12 N·m (106 lb in).
7. Install the spark plug wires onto the spark plugs.



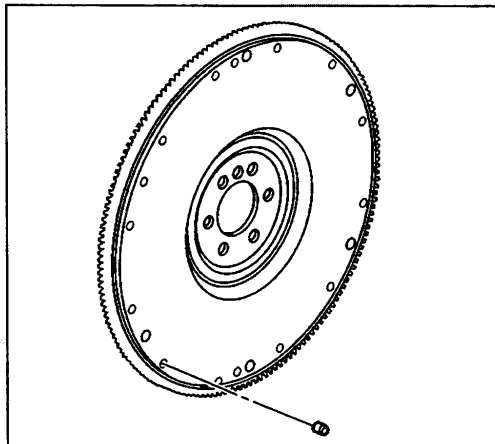
373138

SIE-ID - 375499

Clutch Pilot Bearing Installation

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Install the NEW clutch pilot bearing.
2. Measure to ensure the proper installation depth is obtained.



64126

SIE-ID - 66871

Engine Flywheel Installation

SIO-ID - 66957

Important: If replacing the engine flywheel (manual transmission), note the position of the original flywheel weights (if applicable). Flywheel weights must be installed into the new engine flywheel (manual transmission) in the same location.

1. Note the position of the flywheel weights (manual transmission applications), install the NEW flywheel weights as required.

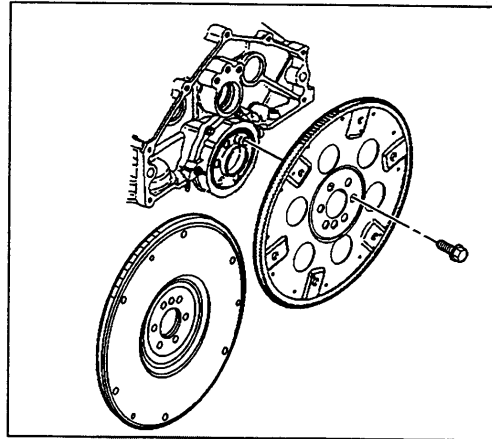
A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

Engine

Engine Mechanical - 5.0L, 5.7L 6-243

2. Install the engine flywheel.

Align the engine flywheel locator hole to the flywheel locator pin.



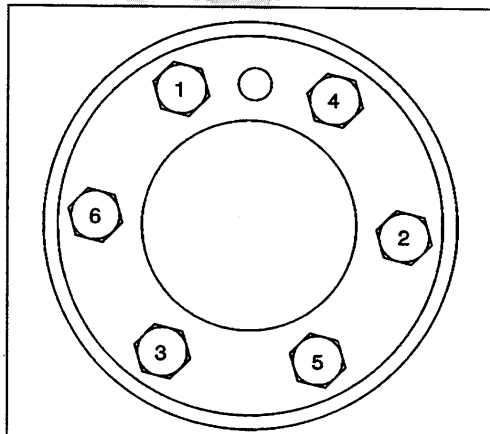
69012

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the engine flywheel bolts.

Tighten

Tighten the engine flywheel bolts in sequence (1–8) to 100 N·m (74 lb ft).



63174

SIE-ID - 69044

Engine Set-Up and Testing

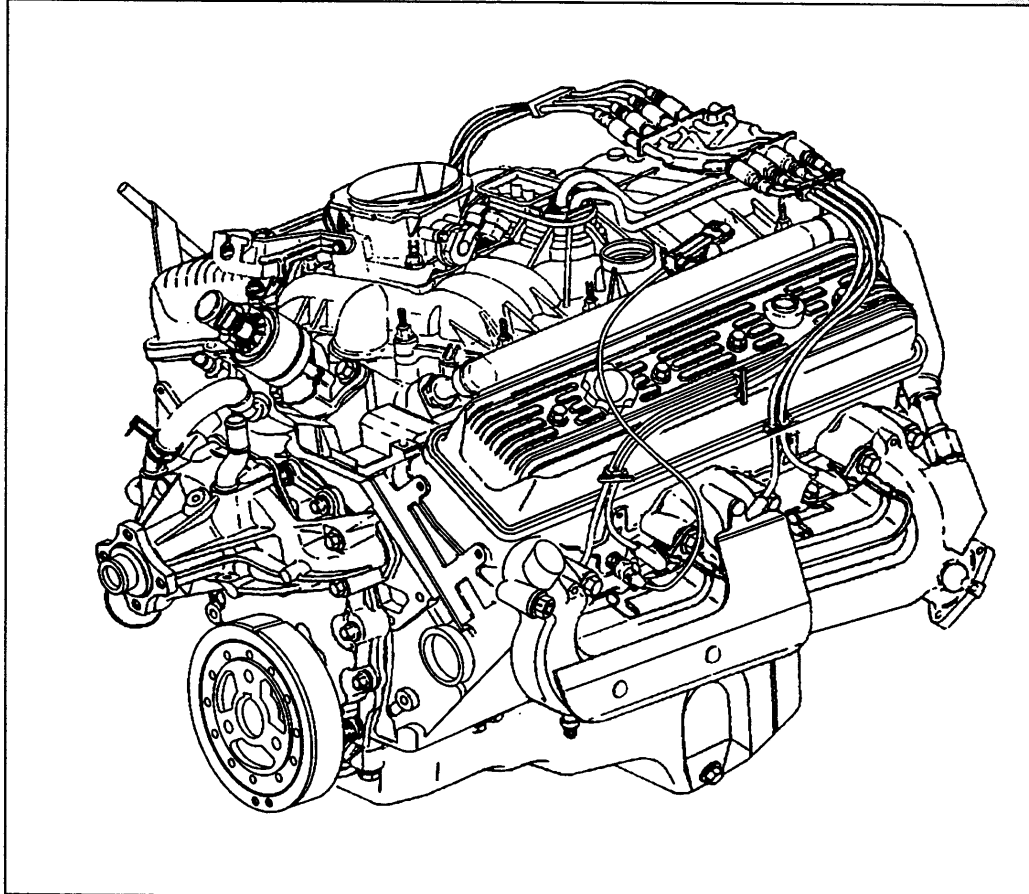
After overhaul, the engine must be tested before it is installed in the vehicle. If a suitable test stand is not available, the following procedure can be used after the engine is installed in the vehicle.

1. Fill the crankcase with the proper quantity and grade of oil.
2. Add engine oil supplement GM P/N 1052367 or equivalent to the engine oil.
3. Fill the cooling system with the proper quantity and grade of coolant.
 - Whenever the cooling system is serviced or drained for service procedures, two cooling system sealing pellets GM P/N 3634621 or equivalent, must be added to the cooling system.
 - Cooling system sealing pellets must be crushed prior to installation. The cooling system sealing pellets must be added to the radiator or the pressurized coolant reservoir.
 - Do not place the cooling system sealing pellets into a non-pressurized coolant recovery reservoir. On these systems, the pellets must be added to the radiator.
 - The sealant pellets may leave a film on the sides of the pressurized and non-pressurized coolant recovery reservoirs. This film is normal.
4. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any of the parts are binding.
5. Start the engine and listen for unusual noises.
6. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.

If necessary, install an oil pressure gauge and measure the engine oil pressure.
7. Operate the engine at about 1000 RPM until the engine has reached normal operating temperature.
8. Listen for improperly adjusted or sticking valves, sticking valve lifters, or other unusual noises.
9. Inspect for oil and/or coolant leaks while the engine is operating.
10. Verify that the distributor is properly positioned/adjusted (Camshaft Retard Offset procedure).
11. Perform a final inspection for the proper engine oil and coolant levels.

Description and Operation

SIE-ID - 69042

Engine Component Description**Cylinder Block**

The engine block is made of cast iron and has eight cylinders arranged in a V shape with four cylinders in each bank. The cylinder block is a one piece casting with the cylinders encircled by coolant jackets.

Cylinder Head

The cylinder heads are made of cast iron. The valve guides and valve seats are machined surfaces integral to the cylinder head. The 5.7L heavy duty applications have pressed in exhaust valve seats. The spark plugs are located between the intake and exhaust ports.

Camshaft

A steel engine camshaft is supported by five

camshaft bearings pressed into the engine block. The camshaft sprocket, mounted to the front of the engine camshaft, is driven by the crankshaft sprocket through a camshaft timing chain.

Motion from the engine camshaft is transmitted to the valves by hydraulic roller valve lifters, valve pushrods, and ball-pivot type valve rocker arms.

Crankshaft

The crankshaft is made of cast nodular iron. The crankshaft is supported by five crankshaft bearings. The crankshaft bearings are retained by the crankshaft bearing caps, which are machined with the engine block for proper alignment and clearances. Light duty 5.0L and 5.7L engines have two bolts per crankshaft bearing cap. The heavy duty 5.7L engines have four bolts per crankshaft bearing

cap, on bearing caps 2, 3, and 4. The number 5 crankshaft bearing cap at the rear of the engine is the end thrust bearing cap. The four connecting rod journals (two connecting rods per journal) are spaced 90 degrees apart. The crankshaft position sensor reluctor ring is pushed onto the front of the crankshaft. The crankshaft position sensor reluctor ring has four lugs used for crankshaft timing and it is constructed of powdered metal. The reluctor ring has an interference fit onto the crankshaft and an internal keyway for correct positioning.

Pistons and Connecting Rods

The pistons are made of cast aluminum that use two compression rings and one oil control ring assembly. The piston is a low-friction, lightweight design with a flat top and barrel-shaped skirt. The piston pins are chromium steel. The piston pins have a floating fit in the piston and are retained by a press fit in the connecting rod assembly. The connecting rods are made out of either forged powdered metal or forged steel. The connecting rods are machined with the connecting rod cap installed for proper clearances and alignment.

Valve Train

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular valve pushrods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic roller valve lifters keep all parts of the valve train in constant contact. The valve rocker arm ball is retained on the valve rocker arm ball stud with a locking nut. The valve rocker arm ball studs are pressed into the cylinder head.

Intake Manifold

The intake manifold is a two piece design. The upper intake manifold portion is made from a composite material and the lower intake manifold portion is cast-aluminum. The throttle body mounts to the upper intake manifold. The lower intake manifold has an exhaust gas recirculation (EGR) port cast into the manifold for mixture of exhaust gases with the fuel and air mixture. The EGR valve mounts to the lower intake manifold.

The Central Sequential Multiport Fuel Injection, Central (SFI) system uses multiple injectors to meter and distribute fuel to each engine cylinder. The Central (SFI) unit is retained by a bracket bolted to the lower intake manifold. The TBI fuel meter also houses the pressure regulator. Metal inlet and outlet fuel lines and nylon delivery tubes independently distribute fuel to each cylinder through nozzles located at the port entrance of each manifold runner where the fuel is atomized.

SIE-ID - 348429

New Product Information

The purpose of New Product Information is to highlight or indicate important product changes from the previous model year.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

- Cylinder head bolts, crankshaft bearing cap bolts, and connecting rod bolts apply a torque angle strategy.

In an on-vehicle situation where a torque angle meter may not fit into the vehicle packaging, a three step tightening process may be used with a torque wrench.

- Certain fasteners should not be reused. Bolts, studs, or other fasteners that must be replaced will be called out in the specific service procedure.

Changed Engine Specifications

Engine specifications remain the same as the 1998 products.

Disassembly and Assembly Procedure Revisions and Additions

- A new design Teflon® crankshaft rear oil seal installation procedure
- Engine block plug information has been enhanced to include the engine oil pressure gauge sensor and the engine oil pressure gauge sensor fitting.
- Clutch pilot bearing removal and installation procedure has been added

Engine Mechanical Diagnostic Procedure Revisions

- Valve Train diagnostic information is now provided in table form. Potential or probable causes are supplied for each specific concern.
- Engine Noise diagnostic information is now provided in table form. Potential or probable causes are supplied for each specific concern.

New Special Tools Required

- Tool J 35621-B is a revision of J 35621-A and services ALL applications.
- Tool J 41712 has been added for the removal and installation of the oil pressure gauge sensor.
- Tool J 43276 has been added for the removal of the clutch pilot bearing.

Refer to *Special Tools*.

*SIE-ID = 195404***Engine Identification**

The Vehicle Identification Number (VIN) is located on the left side rear of the engine block (near the transmission bellhousing) and typically is a nine digit number stamped onto the engine at the vehicle assembly plant.

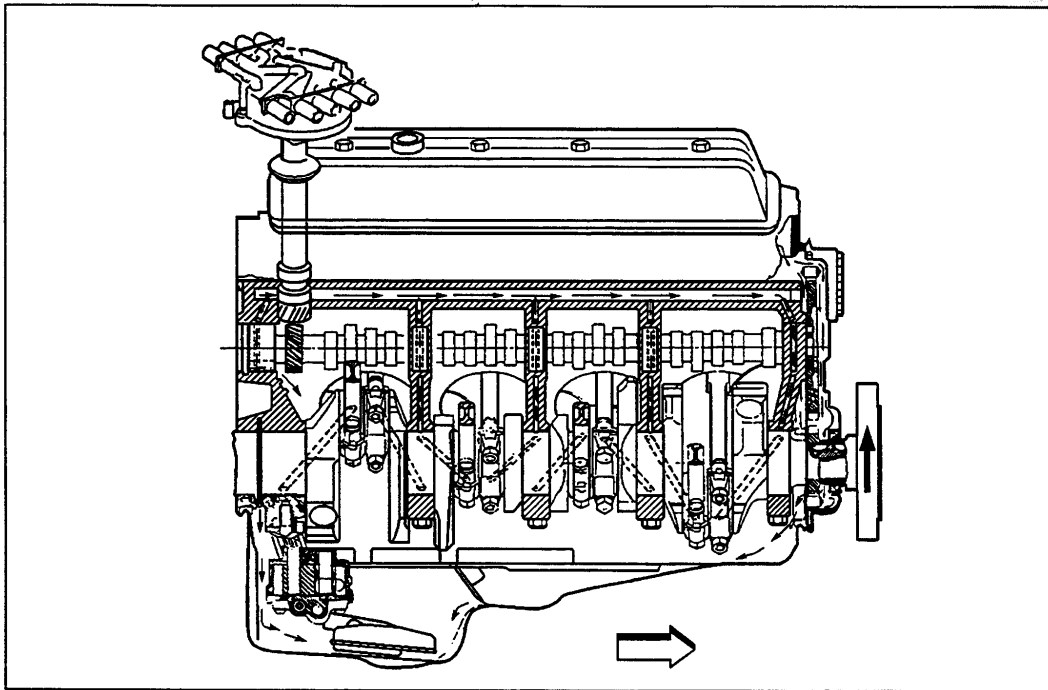
- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

*SIE-ID = 66834***Lubrication**

The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the distributor which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube. Pressurized oil is delivered through internal passages in order to lubricate the camshaft and the crankshaft bearings and to provide lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve pushrods in order to lubricate the valve rocker arms and valve rocker arm ball pivots. Oil returning to the oil pan from the cylinder heads and the camshaft front bearing, lubricates the camshaft timing chain and the crankshaft and the camshaft sprockets.

SIO-ID = 71039

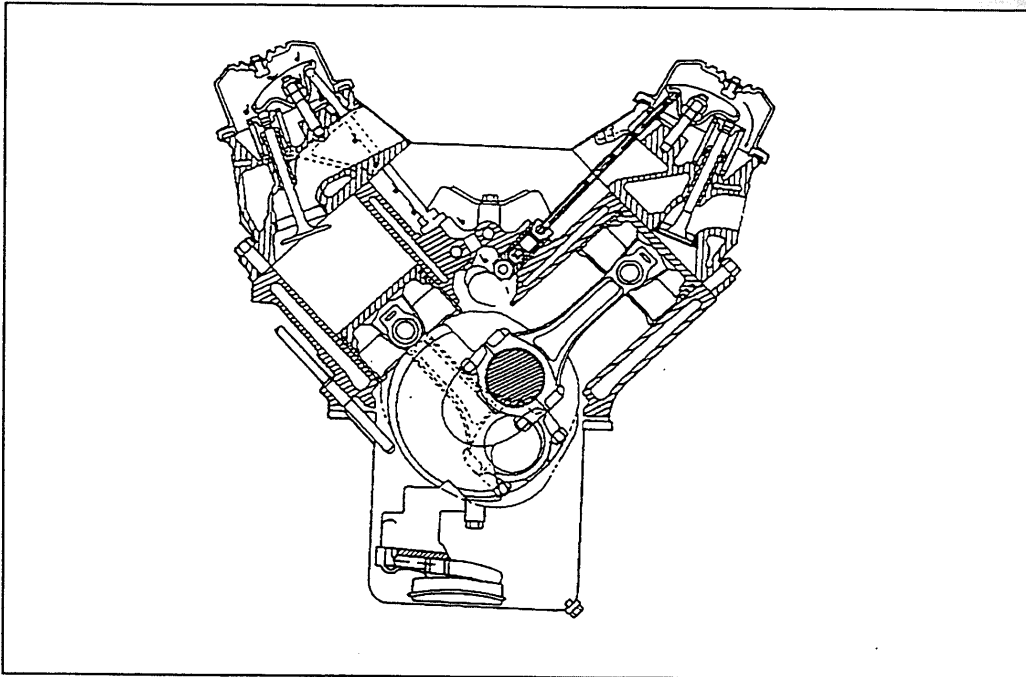
Right Side View



SIO-ID = 71037

67757

Front View



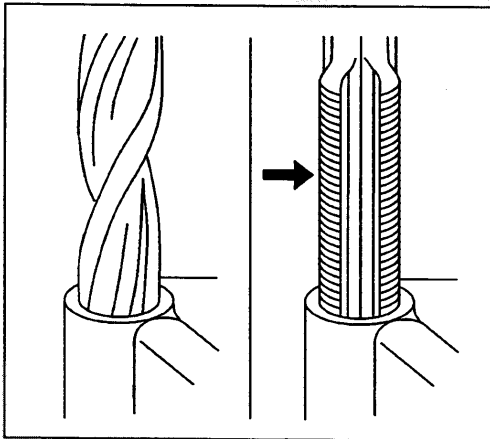
67753

S1E-ID - 43119

Thread Repair

Tools Required

General purpose thread repair kits. These kits are available commercially.



4962

Caution: S1O-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

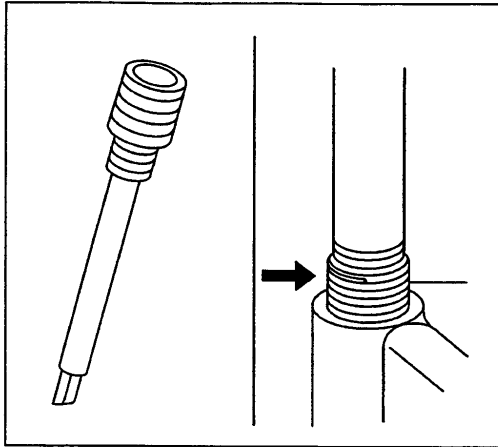
Important: Refer to the kit manufacturer's

1999 - C/K Truck - C

instructions regarding the size of the drill and which tap to use.

Avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread.
Adjust the stop collars on the cutting tool as needed. Tap the collars to the required depth.
2. Drill out the damaged thread. Clean out any chips.
3. Tap the hole. Lubricate the tap with light engine oil. Clean the thread.



4963

4. Thread the insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

Important: The insert should be flush to 1 turn below the surface.

5. Lubricate the insert with light engine oil (except when installing in aluminum) and install the insert.
6. If the tang of the insert does not break off when backing out the installer, break off the tang using a drift punch.

SIE-ID = 19007

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, the components should be marked, organized or retained in a specific order for re-assembly.
- At the time of installation, the components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. The surfaces should be protected to avoid component damage.
- Apply a liberal amount of clean engine oil to friction areas during assembly.
- Proper lubrication will protect and lubricate friction areas during initial operation.

SIE-ID = 66654

Replacing Engine Gaskets

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.
Do not use any other method or technique to remove the sealant or the gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.
 This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.
- Tighten fasteners to the proper specifications. DO NOT overtighten the fasteners.

SIE-ID = 411537

Use of RTV and Anaerobic Sealer

Sealant Types

Important: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant (or equivalent) as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
 - Gasket eliminator
 - Pipe
 - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

Important: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch (within 3 minutes). Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2

rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange. The surfaces to be sealed must be clean and dry.

Important: Do not allow the gasket eliminator sealant to enter any blind threaded holes, as the gasket eliminator sealant may prevent the fasteners from clamping properly, seating properly, or cause damage when the fastener is tightened.

- Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
- **Important:** Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than five minutes, may result in incorrect shimming and sealing of the joint.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.
- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

Important: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than five minutes, may result in incorrect clamp load of assembled components.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

Important: Do not allow the pipe sealant to enter any of the blind threaded holes, as the pipe sealant may prevent the fastener from clamping properly, or cause component damage when the fastener is tightened.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

SIE-ID = 194497

Separating Parts

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When disassembling the engine, internal components **MUST** be separated, marked and organized in a way to ensure reinstallation to original location and position.

Mark or identify the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the specific cylinder bore
- Connecting rod to the crankshaft journal
- Connecting rod to connecting rod cap
- Crankshaft bearings and connecting rod bearings
- Engine camshaft and valve lifters
- Valve lifters and valve rocker arms
- Valve to the valve guide
- Valve spring to cylinder head location
- Engine block bearing cap location and direction
- Oil pump drive and driven gears

SIE-ID = 73997

Tools and Equipment

SIO-ID = 70760

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well-lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

Special Tools and Equipment

S/E-ID = 348394

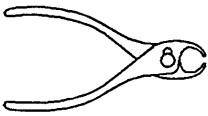
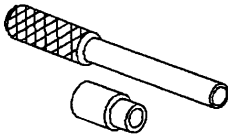
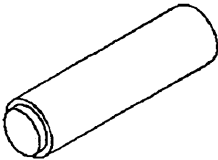
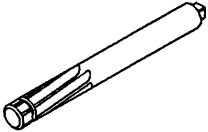
Illustration	Tool Number/ Description
 14487	J 3049-A Valve Lifter Remover
 3404	J 5239 Connecting Rod Bolt Guide Set
 3407	J 5590 Installer
 14492	J 5715 or J 6036 Reamer

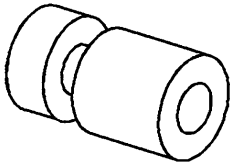
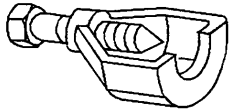

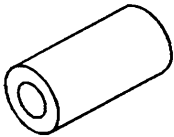
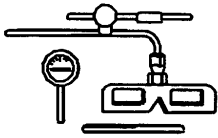
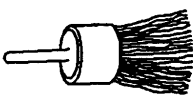
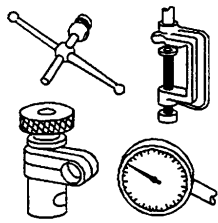
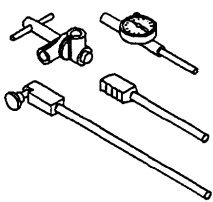
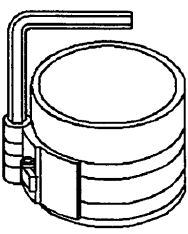
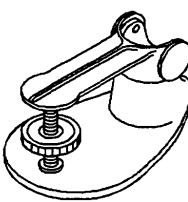
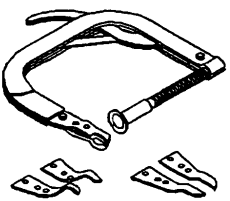

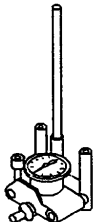
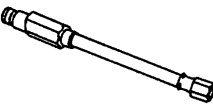
Illustration	Tool Number/ Description
 35460	J 5802-01 Rocker Arm Stud Remover
 3406	J 5825-A Crankshaft Gear Remover
 3399	J 5892-D Valve Spring Compressor
 35461	J 6880 Rocker Arm Stud Installer

Illustration	Tool Number/ Description	Illustration	Tool Number/ Description
 <p>35463</p>	J 7872 Magnetic Base Dial Indicator	 <p>35464</p>	J 8089 Carbon Removing Brush
 <p>2014</p>	J 8001 Dial Indicator Set	 <p>3408</p>	J 8520 Cam Lobe Lift Indicator
 <p>3403</p>	J 8037 Ring Compressor	 <p>5112</p>	J 9666 Valve Spring Tester
 <p>3414</p>	J 8062 Valve Spring Compressor	 <p>3416</p>	J 21882 Oil Suction Pipe Installer
 <p>5110</p>	J 8087 Cylinder Bore Gauge	 <p>26998</p>	J 22794 Spark Plug Port Adapter

Engine

Engine Mechanical - 5.0L, 5.7L 6-255

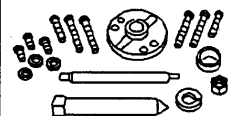
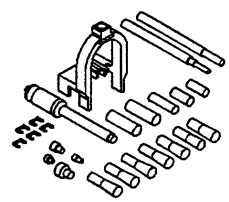
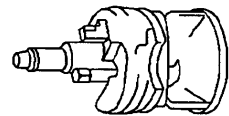
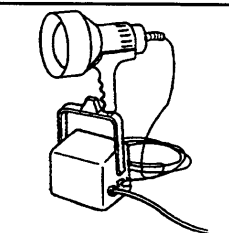
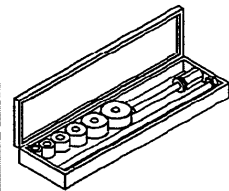
Illustration	Tool Number/ Description
 66168	J 23523-F Balancer Remover and Installer
 14495	J 24086-C Piston Pin Remover/Installer Set
 3412	J 24270 Cylinder Bore Ridge Reamer
 62292	J 28428-E High Intensity Black Light Kit
 5118	J 33049 Camshaft Bearing Service Set

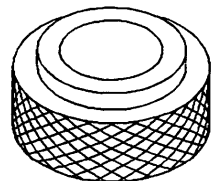
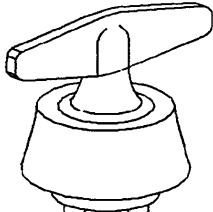
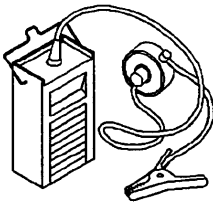
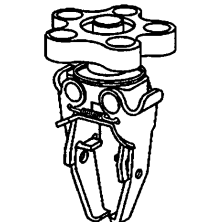
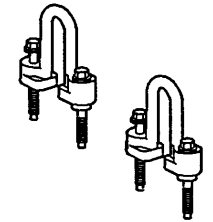
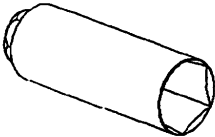
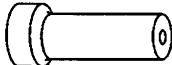
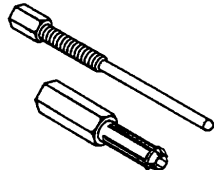
Illustration	Tool Number/ Description
 3401	J 35468 Cover Aligner/Seal Installer
 350498	J 35621-B Rear Main Seal Installer
 3413	J 36660 Electronic Torque Angle Meter
 33658	J 38606 Valve Spring Compressor
 66511	J 41427 Engine Lift Brackets

Illustration	Tool Number/ Description
 67136	J 41712 Oil Pressure Switch Socket
 38509	J 42073 Valve Stem Seal Installer
 355040	J 43276 Clutch Pilot Bearing Remover

**POWER SHIFT
TRANSMISSION
32000
MAINTENANCE AND SERVICE**

TOWING OR PUSH STARTING

Before towing the vehicle, be sure to lift the drive axle off the ground or disconnect the driveline to avoid damage to the transmission during towing.

The engine cannot be started by pushing or towing.

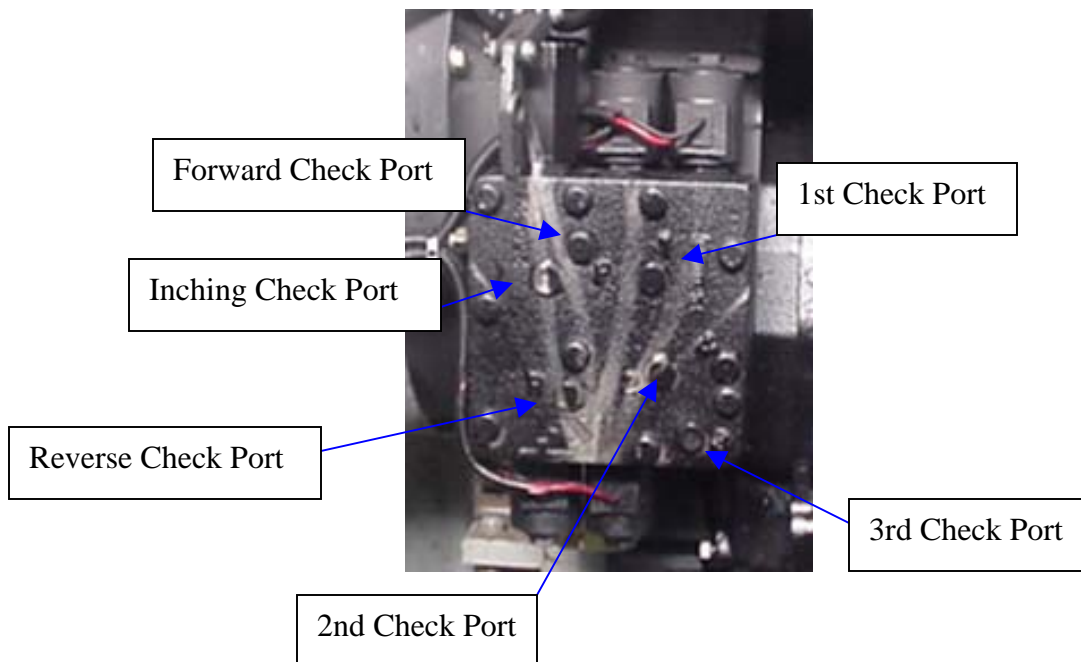
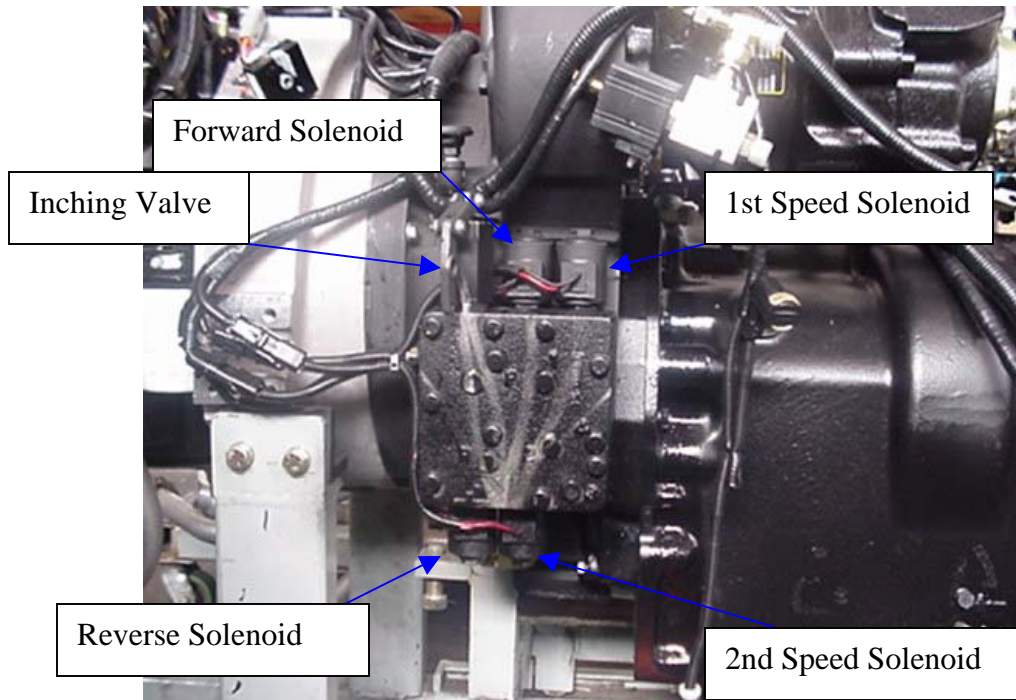
Transmission Filter

NOTE: This picture was taken from under side of the truck

Change the transmission filter every 250hrs located next to the hydraulic tank. Use SAE 30



32000 Transmission Control Valve



Clutch pressure 240-300 PSI with parking brake set, oil temperature 180 –200 F and engine idle 400 to 600 RPM. Shift thru the direction and speed clutches NOTE: all pressure must be equal within 5 PSI if clutch pressure varies in any one clutch more than 5 PSI repair the clutch.

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HOW THE UNITS OPERATE

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NOTE: Metric Dimensions Shown in Brackets [].

TRANSMISSION ASSEMBLY

The transmission and hydraulic torque portion of the power train enacts an important role in transmitting engine power to the driving wheels. In order to properly maintain and service these units it is important to first understand their function and how they operate.

The transmission and torque converter function together and operate through a common hydraulic system. It is necessary to consider both units in the study of their function and operation.

To supplement the text below, and for reference use therewith, the following illustrations are provided:

- Basic Design Silhouette
- Converter Group
- Converter and Transmission Case Group
- 3 & 4 Speed Clutch and Gear Group
- Regulating Valve, Charging Pump and Filter Group
- Control Valve Assembly (Mechanical & Electric Shift)
- Mechanical Parking Brake
- Assembly Instruction
- Ring Gear Installation
- Clutch and Gear Arrangement
- Shielded Bearing Installation
- 3 & 4 Speed Power Flow
- External Plumbing
- 4 Speed Section

The R, HR, and MHR Model Transmissions are of three basic designs.

The R Model consists of a separate torque converter, mounted to the engine with the powershift transmission remotely mounted and connected to the torque converter with a drive shaft.

The HR Model consists of a torque converter and powershifted transmission in one package mounted directly to the engine.

The MHR version is a mid-mount torque converter and transmission assembly connected to the engine by means of a drive shaft. (See Fig. A for basic design silhouette.)

The shift control valve assembly may be mounted directly on the side of the converter housing or front transmission cover, or remote mounted and connected to the transmission by means of flexible hoses. The function of the control valve assembly is to direct oil under pressure to the desired directional and speed clutch. A provision is made on certain models to neutralize the transmission when the brakes are applied. This is accomplished through use of a brake actuated shutoff valve. The speed and direction clutch assemblies are mounted inside the transmission case and are connected to the output shaft of the converter either by direct gearing or drive shaft. The purpose of the speed or directional clutches is to direct the power flow through the gear train to provide the desired speed range and direction.

An axle disconnect is optional and is located on the output shaft. The drive to the front or rear axle can be disconnected or connected by manual shifting.

HOW THE UNITS OPERATE

With the engine running, the converter charging pump draws oil from the transmission sump through the removable oil suction screen and directs it through the pressure regulating valve and oil filter.

The pressure regulating valve maintains pressure to the transmission control cover for actuating the direction and speed clutches. This requires a small portion of the total volume of oil used in the system. The remaining volume of oil is directed through the torque converter circuit to the oil cooler and returns to the transmission for positive lubrication. This regulator valve consists of a hardened valve spool operating in a closely fitted bore. The valve spool is spring loaded to hold the valve in a closed position. When a specific pressure is achieved, the valve spool works against the spring until a port is exposed along the side of the bore. This sequence of events provides the proper system pressure.

After entering the converter housing the oil is directed through the stator support to the converter blade cavity and exits in the passage between the turbine shaft and converter support. The oil then flows out of the converter to the oil cooler. After leaving the cooler, the oil is directed to a fitting on the transmission. Then through a series of tubes and passages lubricates the transmission bearings and clutches. The oil then gravity drains to the transmission sump.

The hydraulic torque converter consists basically of three elements and their related parts to multiply engine torque. The engine power is transmitted from the engine flywheel to the impeller element through the impeller cover. This element is the pump portion of the hydraulic torque converter and is the primary component which starts the oil flowing to the other components which results in torque multiplication. This element can be compared to a centrifugal pump in that it picks up fluid at its center and discharges at its outer diameter.

The torque converter turbine is mounted opposite the impeller and is connected to the output shaft of the torque converter. This element receives fluid at its outer diameter and discharges at its center. Fluid directed by the impeller out into the particular design of blading in the turbine and reaction member is the means by which the hydraulic torque converter multiplies torque.

The reaction member of the torque converter is located between and at the center or inner diameters of the impeller and turbine elements. Its function is to take the fluid which is exhausting from the inner portion of the turbine and change its direction to allow correct entry for recirculation into the impeller element.

The torque converter will multiply engine torque to its designed maximum multiplication ratio when the output shaft is at zero RPM. Therefore, we can say that as the output shaft is decreasing in speed the torque multiplication is increasing.

The shift control valve assembly consists of a valve body with selector valve spools. A detent ball and spring in the selector spool provides one position for each speed range. A detent ball and spring in the direction spool provides three positions, one each for forward, neutral and reverse.

With the engine running and the directional control lever in neutral position, oil pressure from the regulating valve is blocked at the control valve, and the transmission is in neutral. Movement of the forward and reverse spool will direct oil, under pressure to either the forward or reverse direction clutch as desired.

When either directional clutch is selected the opposite clutch is relieved of pressure and vents back through the direction selector spool. The same procedure is used in the speed selector.

The direction or speed clutch assembly consists of a drum with internal splines and a bore to receive a hydraulically actuated piston. The piston is "oil tight" by the use of sealing rings. A steel disc with external splines is inserted into the drum and rests against the piston. Next, a friction disc with splines at the inner diameter is inserted. Discs are alternated until the required total is achieved. A heavy back-up plate is then inserted and secured with a snap ring. A Hub with O.D. splines is inserted into the splines of discs with teeth on the inner diameter. The discs and hub are free to increase in speed or rotate in the opposite direction as long as no pressure is present in that specific clutch.

To engage the clutch, as previously stated, the control valve is placed in the desired position. This allows oil under pressure to flow from the control valve, through a tube, to a chosen clutch shaft. This shaft has a drilled passageway for oil under pressure to enter the shaft. Oil pressure sealing rings are located on the clutch shaft. These rings direct oil under pressure to a desired clutch. Pressure of the oil forces the piston and discs against the heavy back-up plate. The discs, with teeth on the outer diameter, clamping against discs with teeth on the inner diameter, enables the hub and clutch shaft to be locked together and allows them to drive as a unit.

There are bleed balls in the clutch piston which allow quick escape for oil when the pressure to the piston is released.

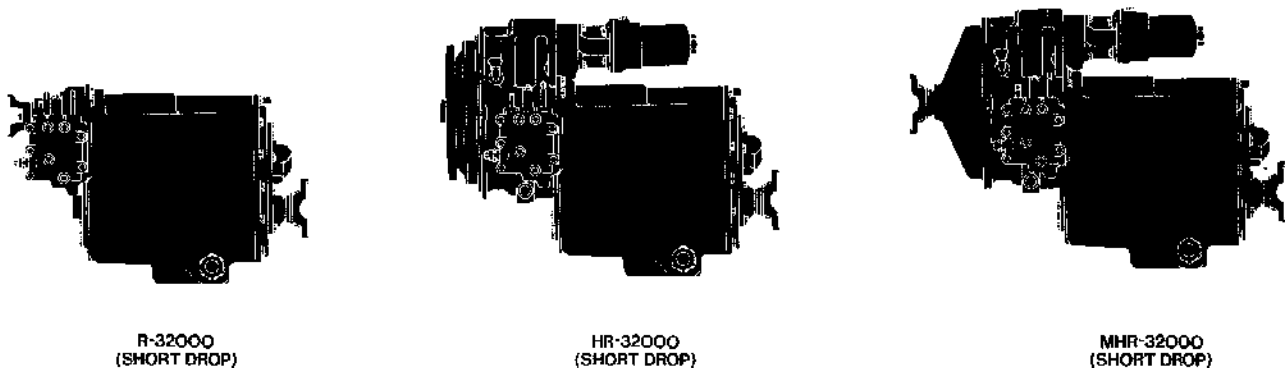


FIG. A

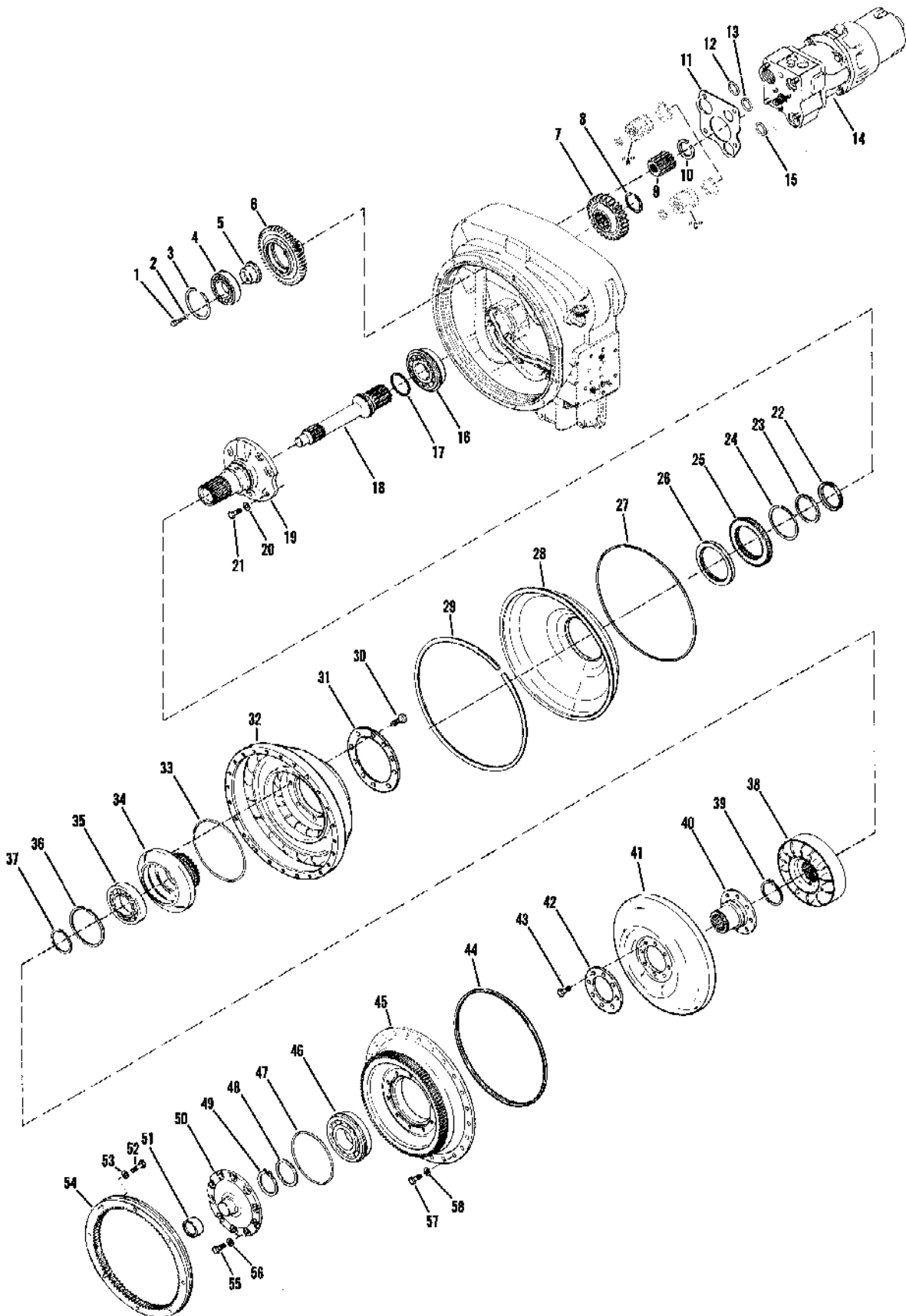


Figure B

HR32000 CONVERTER GROUP

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Bearing Support Screw	6	30	Hub to Impeller Screw.....	12
2	Bearing Support Screw Lockwasher...	6	31	Impeller Hub Screw Backing Ring	1
3	Drive Gear Snap Ring	3	32	Impeller.....	1
4	Pump Drive Gear Bearing	3	33	Impeller Hub "O" Ring	1
5	Pump Drive Bearing Support.....	3	34	Impeller Hub.....	1
6	Pump Drive Gear	3	35	Impeller Hub Bearing.....	1
7	Turbine Shaft Gear.....	1	36	Bearing Snap Ring.....	1
8	Turbine Shaft Gear Snap Ring	1	37	Reaction Member Spacer	1
9	Charging Pump Drive Sleeve.....	1	38	Reaction Member.....	1
10	Pump Sleeve Snap Ring	1	39	Reaction Member Snap Ring	1
11	Valve to Housing Gasket.....	1	40	Turbine Hub	1
12	Valve Body "O" Ring	1	41	Turbine	1
13	Valve Body "O" Ring	1	42	Turbine Hub Backing Ring	1
14	Charging Pump & Oil Filter Assembly ...	1	43	Turbine Hub Screw	8
15	Valve Body "O" Ring	1	44	Impeller to Cover "O" Ring.....	1
16	Turbine Shaft Bearing	1	45	Impeller Cover	1
17	Turbine Shaft Piston Ring.....	1	46	Impeller Cover Bearing	1
18	Turbine Shaft	1	47	Bearing Cap to Impeller Cover "O" Ring	1
19	Stator Support	1	48	Bearing Washer	1
20	Stator Support Screw Lockwasher....	6	49	Bearing Snap Ring.....	1
21	Stator Support Screw.....	6	50	Impeller Cover Bearing Cap.....	1
22	Piston Ring	1	51	Impeller Cover Sleeve	1
23	Piston Ring Expander Spring	1	52	Ring Gear Screw	16
24	Impeller Hub Gear Snap Ring.....	1	53	Plain Washer.....	16
25	Impeller Hub Gear	1	54	Flywheel Ring Gear	1
26	Oil Baffle Oil Seal.....	1	55	Bearing Cap to Impeller Cover Screw ...	10
27	Oil Baffle Seal Ring	1	56	Bearing Cap to Impeller Cover Screw Lockwasher.....	10
28	Oil Baffle	1	57	Impeller to Cover Screw	24
29	Oil Baffle Retainer Ring.....	1	58	Impeller to Cover Screw Lockwasher ...	24

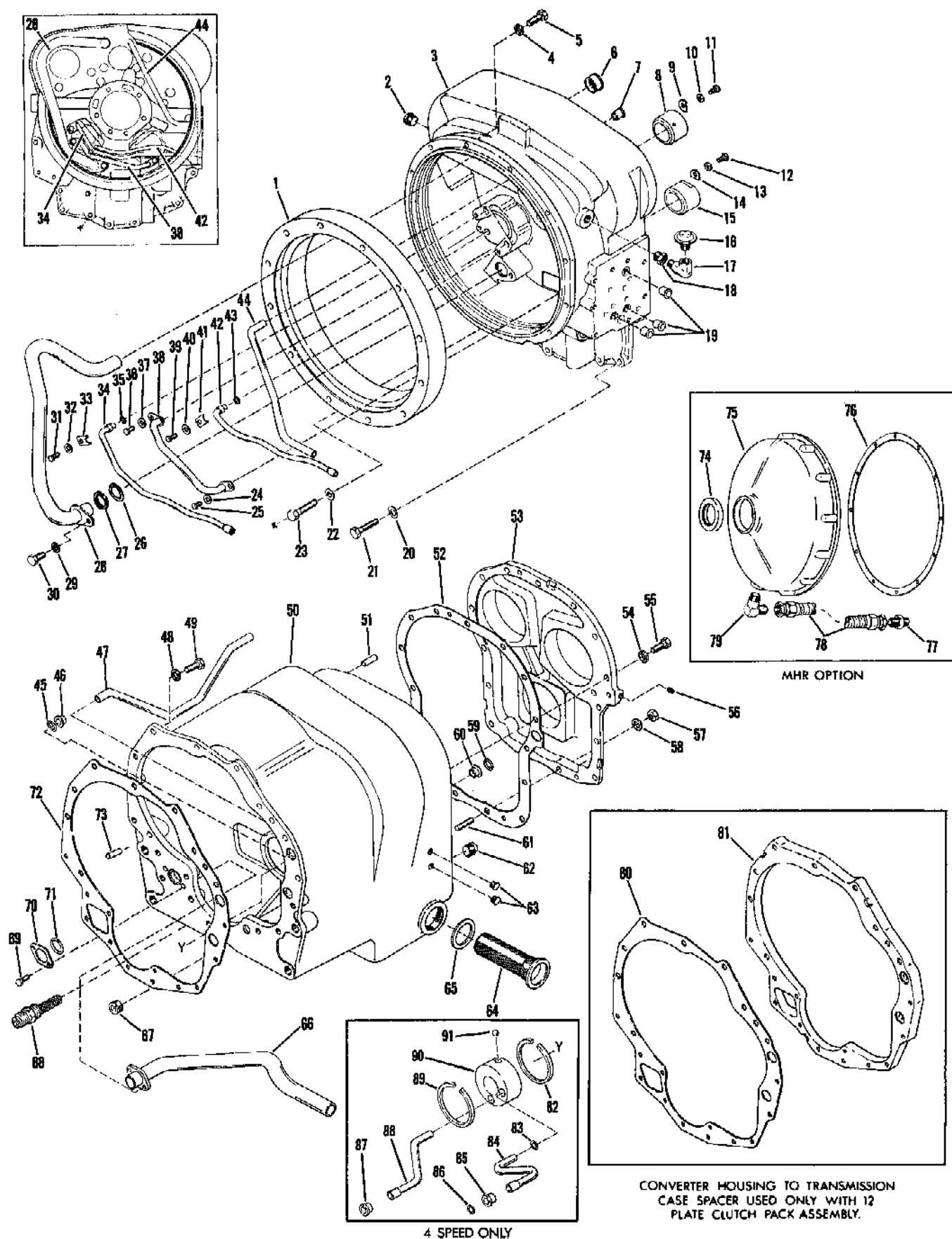


Figure C

**32000 CONVERTER HOUSING, TRANSMISSION CASE
& REAR COVER GROUP 3 & 4 SPEED, SHORT DROP
FOR R-MODEL FRONT COVER GROUP SEE R-MODEL SECTION**

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Converter Housing Adaptor Ring	1	46	Tube Sleeve	1
2	Pipe Plug	1	47	Low Speed Clutch Pressure Tube	1
3	Converter Housing & Tube Assembly	1	48	Transmission Case to Converter Housing Screw Lockwasher	10
4	Converter Housing to Front Cover Screw Lockwasher	12	49	Transmission Case to Converter Housing Screw	10
5	Converter Housing to Front Cover Screw	12	50	Transmission Case Assembly	1
6	Tube Sleeve	1	51	Transmission Case to Rear Cover Dowel Pin	2
7	Tube Sleeve	1	52	Transmission Case to Rear Cover Gasket	1
8	Converter Housing Sleeve	1	53	Transmission Case Rear Cover	1
9	Converter Housing Sleeve Lock	1	54	Rear Cover to Case Screw Lockwasher	13
10	Converter Housing Sleeve Screw Lockwasher	1	55	Rear Cover to Case Screw	13
11	Converter Housing Sleeve Screw	1	56	Rear Cover Pipe Plug	1
12	Converter Housing Sleeve Screw	1	57	Rear Cover to Transmission Case Stud Nut	2
13	Converter Housing Sleeve Screw Lockwasher	1	58	Rear Cover to Transmission Case Lockwasher	2
14	Converter Housing Sleeve Lock	1	59	Tube Sleeve "O" Ring	1
15	Converter Housing Sleeve	1	60	Tube Sleeve	1
16	Breather	1	61	Transmission Case to Rear Cover Stud	2
17	Street Ell	1	62	Drain Plug	1
18	Breather Reducing Bushing	1	63	Oil Level Plug	2
19	Tube Sleeve	3	64	Screen Assembly	1
20	Converter Housing to Transmission Housing Screw Lockwasher	4	65	Screen Assembly Gasket	1
21	Converter Housing to Transmission Housing Screw	4	66	Suction Tube Assembly	1
22	Converter Housing to Transmission Housing Lockwasher	4	67	Pipe Plug	1
23	Converter Housing to Transmission Housing Screw	4	68	Suction Screen Assembly	1
24	Lube Tube Retaining Screw Lockwasher	1	69	Suction Tube Retainer Washer Screw	2
25	Lube Tube Retaining Screw	1	70	Suction Tube Retainer Washer	1
26	Suction Tube "O" Ring	1	71	Suction Tube "O" Ring	1
27	Suction Tube Spacer Ring	1	72	Converter Housing to Transmission Case Gasket	1
28	Suction Tube Assembly	1	73	Converter Housing to Transmission Case Dowel Pin	2
29	Suction Tube Retainer Screw Lockwasher	1	74	Front Cover Oil Seal	1
30	Suction Tube Retainer Screw	1	75	Converter Housing Front Cover	1
31	Tube Clip Screw	1	76	Converter Housing Front Cover Gasket	1
32	Tube Clip Screw Lockwasher	1	77	Hose Fitting	1
33	Tube Clip	1	78	Hose Assembly	1
34	Reverse Tube Assembly	1	79	Hose Fitting	1
35	Reverse Tube "O" Ring	1	80	Converter Housing to Transmission Case Gasket	1
36	Lube Tube Retainer Screw	1	81	Converter Housing to Transmission Case Spacer	1
37	Lube Tube Retainer Screw Lockwasher	1	82	Oil Distributor Retainer Ring	1
38	Lube Tube Assembly	1	83	Pressure Tube "O" Ring	1
39	Tube Clip Screw	1	84	4th Clutch Pressure Tube	1
40	Tube Clip Screw Lockwasher	1	85	Tube Sleeve	1
41	Tube Clip	1	86	Pressure Tube "O" Ring	1
42	3rd Speed Tube Assembly	1	87	Tube Sleeve	1
43	3rd Speed Tube "O" Ring	1	88	4th Clutch Lube Tube	1
44	Valve Oil Supply Tube	1	89	Oil Distributor Retainer Ring	1
45	Pressure Tube "O" Ring	1	90	Oil Distributor	1
			91	Oil Distributor Lock Ball	1

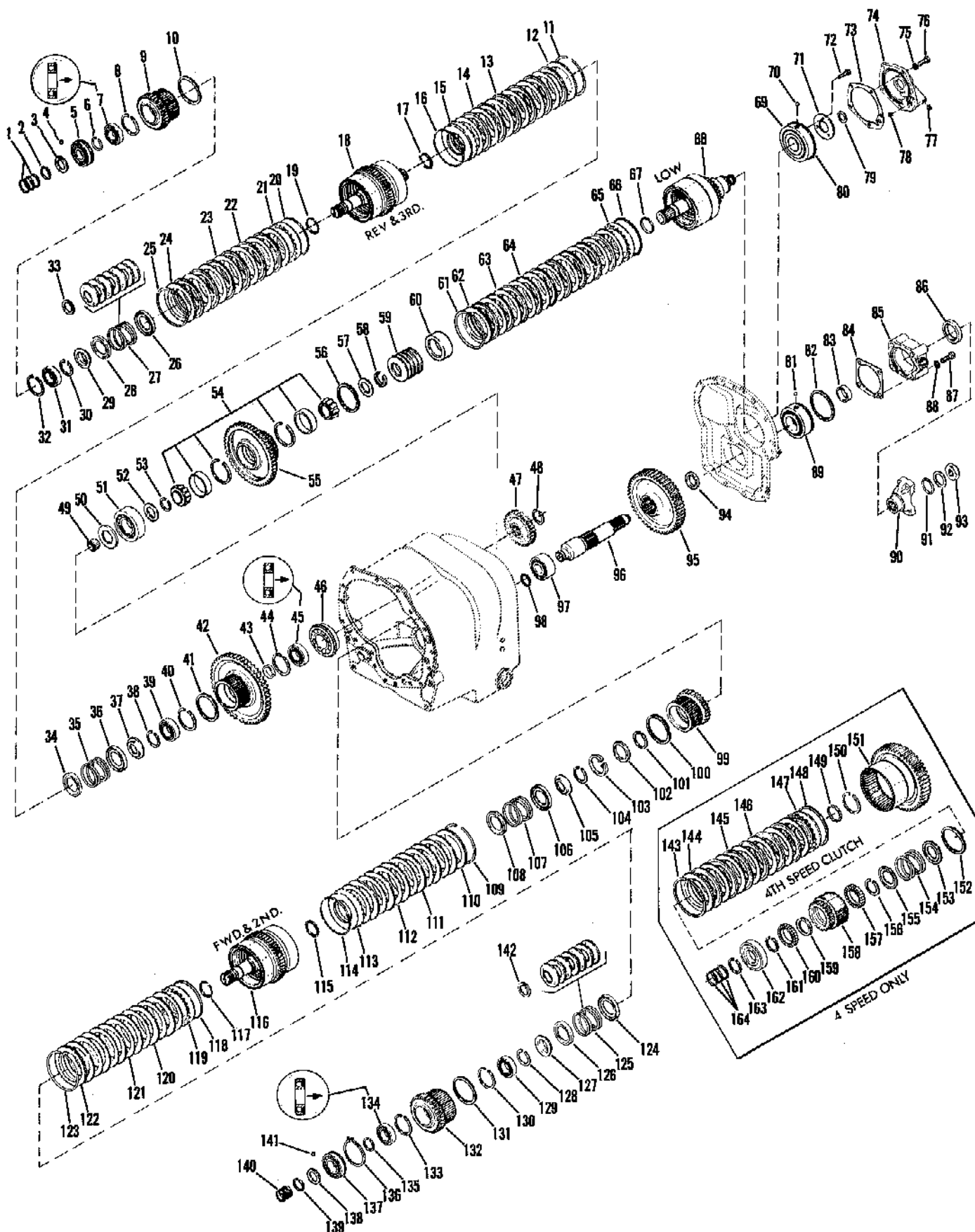


Figure D

R OR HR32000
SHORT DROP 3 & 4 SPEED
CLUTCH & GEAR GROUP

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Reverse & 3rd Clutch Shaft Piston Ring.....	3	43	3rd Gear Bearing Spacer	1
2	Front Bearing Retainer Ring.....	1	44	3rd Gear Bearing Snap Ring	1
3	Reverse & 3rd Shaft Front Bearing End Plate....	1	45	3rd Gear Bearing - Shield Out.....	1
4	Reverse and 3rd Shaft Bearing End Plate		46	Reverse & 3rd Shaft Rear Bearing	1
	Ball	1	47	Low Clutch Drive Gear	1
5	Reverse & 3rd Shaft Front Bearing	1	48	Gear Retaining Ring	1
6	Front Bearing Retainer Ring.....	1	49	Low Speed Clutch Shaft Pilot Bearing	1
7	Clutch Driven Gear Bearing - Shield In	1	50	2nd Gear Bearing End Plate	
8	Clutch Driven Gear Bearing Snap Ring.....	1		(4 Speed Transmission Only).....	1
9	Clutch Driven Gear	1	51	2nd Gear Bearing	1
10	Clutch Hub Oil Baffle Ring	1	52	Bearing Retaining Ring Retainer.....	1
11	End Plate Retainer Ring.....	1	53	Low Speed Gear Bearing Retainer Ring.....	1
12	End Plate - 3rd Clutch	1	54	Low Speed Gear Bearing Assembly	1
13	Clutch Inner Disc - 3rd Clutch.....	6	55	Low Speed Gear	1
14	Clutch Outer Disc - 3rd Clutch.....	6	56	Clutch Hub Oil Baffle Ring.....	1
15	Clutch Piston - 3rd Clutch	1	57	Spring Retaining Ring Retainer.....	1
16	Clutch Piston Outer Seal Ring.....	1	58	Spring Retaining Ring	1
17	Clutch Piston Inner Seal Ring	1	59	Belleville Washer	5
18	Reverse & 3rd Clutch Drum.....	1	60	Piston to Belleville Washer Spacer.....	1
19	Clutch Piston Inner Seal Ring	1	61	End Plate Retainer Ring.....	1
20	Clutch Piston Outer Seal Ring.....	1	62	End Plate	1
21	Clutch Piston Assembly - Reverse Clutch....	1	63	Clutch Outer Disc - Low Clutch.....	9
22	Clutch Inner Disc - Reverse Clutch.....	12	64	Clutch Inner Disc - Low Clutch.....	9
23	Clutch Outer Disc - Reverse Clutch.....	12	65	Clutch Piston - Low Clutch	1
24	End Plate - Reverse Clutch	1	66	Clutch Piston Outer Seal Ring.....	1
25	End Plate Retainer Ring.....	1	67	Clutch Piston Inner Seal Ring	1
26	Spring Retainer.....	1	68	Low Speed Clutch Drum.....	1
27	Piston Return Belleville Washer/Spring	7	69	Low Speed Shaft Rear Bearing	1
28	Spring Retainer.....	1	70	Bearing Lockball	1
29	Spring Retainer Snap Ring Retainer.....	1	71	Rear Bearing Retainer Plate.....	1
30	Spring Retainer Snap Ring.....	1	72	Rear Bearing Retainer Plate Screw.....	3
31	Clutch Driven Gear Bearing	1	73	Rear Bearing Cap Gasket.....	1
32	Clutch Driven Gear Bearing Snap Ring.....	1	74	Rear Bearing Cap	1
33	Spring Retainer Snap Ring.....	1	75	Rear Bearing Cap Screw Lockwasher.....	5
34	Spring Retainer.....	1	76	Rear Bearing Cap Screw.....	5
35	Piston Return Spring.....	1	77	Rear Bearing Cap Plug	1
36	Spring Retainer.....	1	78	Rear Bearing Cap "O" Ring	1
37	Spring Retainer Snap Ring Retainer.....	1	79	Clutch Shaft Piston Ring	1
38	Spring Retainer Snap Ring.....	1	80	Low Speed Shaft Rear Bearing	
39	3rd Gear Bearing.....	1		Locating Ring	1
40	3rd Gear Bearing Snap Ring	1	81	Output Shaft Rear Bearing Lock Ball.....	1
41	Clutch Hub Oil Baffle Ring.....	1	82	Rear Bearing Locating Ring	1
42	3rd Gear.....	1	Continued on next page.		

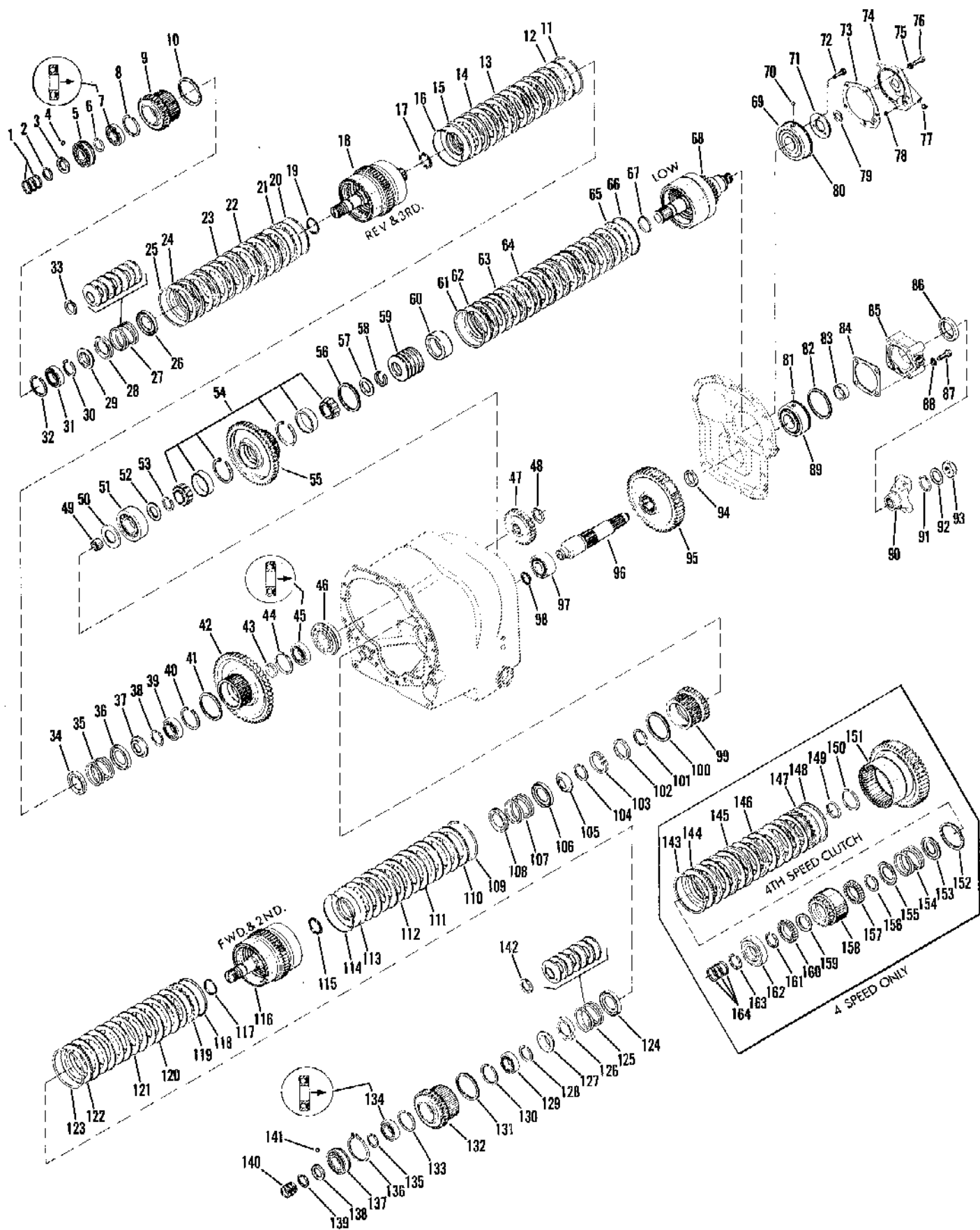


Figure D

R OR HR32000
SHORT DROP 3 & 4 SPEED
CLUTCH & GEAR GROUP
(continued)

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
83	Rear Bearing Spacer.....	1	125	Piston Return Belleville Washer/Spring.....	7
84	Output Shaft Bearing Cap Gasket.....	1	126	Spring Retainer.....	1
85	Output Shaft Rear Bearing Cap.....	1	127	Spring Retainer Snap Ring Retainer.....	1
86	Output Shaft Bearing Cap Oil Seal.....	1	128	Spring Retainer Snap Ring.....	1
87	Rear Bearing Cap Screw.....	4	129	Clutch Driven Gear Bearing.....	1
88	Rear Bearing Cap Screw Lockwasher.....	4	130	Clutch Driven Gear Bearing Snap Ring.....	1
89	Output Shaft Rear Bearing.....	1	131	Clutch Hub Oil Baffle Ring.....	1
90	Output Flange.....	1	132	Forward Clutch Driven Gear.....	1
91	Output Flange "O" Ring.....	1	133	Clutch Driven Gear Bearing Snap Ring.....	1
92	Output Flange Washer.....	1	134	Clutch Driven Gear Bearing - Shield In.....	1
93	Output Flange Nut.....	1	135	Front Bearing Retainer Ring.....	1
94	Output Shaft Gear Spacer.....	1	136	Front Bearing Locating Ring.....	1
95	Output Shaft Gear.....	1	137	Forward & 2nd Shaft Front Bearing.....	1
96	Output Shaft.....	1	138	Forward & 2nd Shaft Front Bearing End Plate.....	1
97	Output Shaft Front Bearing.....	1	139	Front Bearing Retainer Ring.....	1
98	Bearing Retaining Ring.....	1	140	Forward & 2nd Shaft Piston Ring.....	3
99	2nd Gear.....	1	141	Forward & 2nd Shaft Bearing End Plate Ball... ..	1
100	Clutch Hub Oil Baffle Ring.....	1	142	Spring Retainer Snap Ring.....	1
101	2nd Gear Retaining Ring.....	1	143	End Plate.....	1
102	2nd Gear Locating Ring Retainer.....	1	144	End Plate Retainer Ring.....	1
103	2nd Gear Locating Ring Retainer Snap Ring... ..	1	145	Clutch Inner Disc - 4th Clutch.....	6
104	Spring Retainer Snap Ring.....	1	146	Clutch Outer Disc - 4th Clutch.....	6
105	Spring Retainer Snap Ring Retainer.....	1	147	Clutch Piston Assembly - 4th Clutch.....	6
106	Spring Retainer.....	1	148	Clutch Piston Outer Seal Ring.....	1
107	Piston Return Spring.....	1	149	Clutch Piston Inner Seal Ring.....	1
108	Spring Retainer.....	1	150	Not Used On This Model	
109	End Plate Retainer Ring.....	1	151	4th Clutch Drum & Output Gear Assembly... ..	1
110	End Plate - 2nd Clutch.....	1	152	4th Gear Oil Baffle Ring.....	1
111	Clutch Inner Disc - 2nd Clutch.....	6	153	Spring Retainer.....	1
112	Clutch Outer Disc - 2nd Clutch.....	6	154	Piston Return Spring.....	1
113	Clutch Piston Assembly - 2nd Clutch.....	1	155	Spring Retainer.....	1
114	Clutch Piston Outer Seal Ring.....	1	156	Spring Retainer Snap Ring.....	1
115	Clutch Piston Inner Seal Ring.....	1	157	4th Gear Bearing.....	1
116	Forward & 2nd Clutch Drum.....	1	158	4th Gear.....	1
117	Clutch Piston Inner Seal Ring.....	1	159	Bearing Spacer.....	1
118	Clutch Piston Outer Seal Ring.....	1	160	4th Gear Bearing.....	1
119	Clutch Piston Assembly - Forward Clutch... ..	1	161	Bearing Snap Ring.....	1
120	Clutch Inner Disc - Forward Clutch.....	12	162	Output Shaft Front Bearing.....	1
121	Clutch Outer Disc - Forward Clutch.....	12	163	Front Bearing Retainer Ring.....	1
122	End Plate - Forward Clutch.....	1	164	4th Clutch Oil Sealing Ring.....	3
123	End Plate Retainer Ring.....	1			
124	Spring Retainer.....	1			

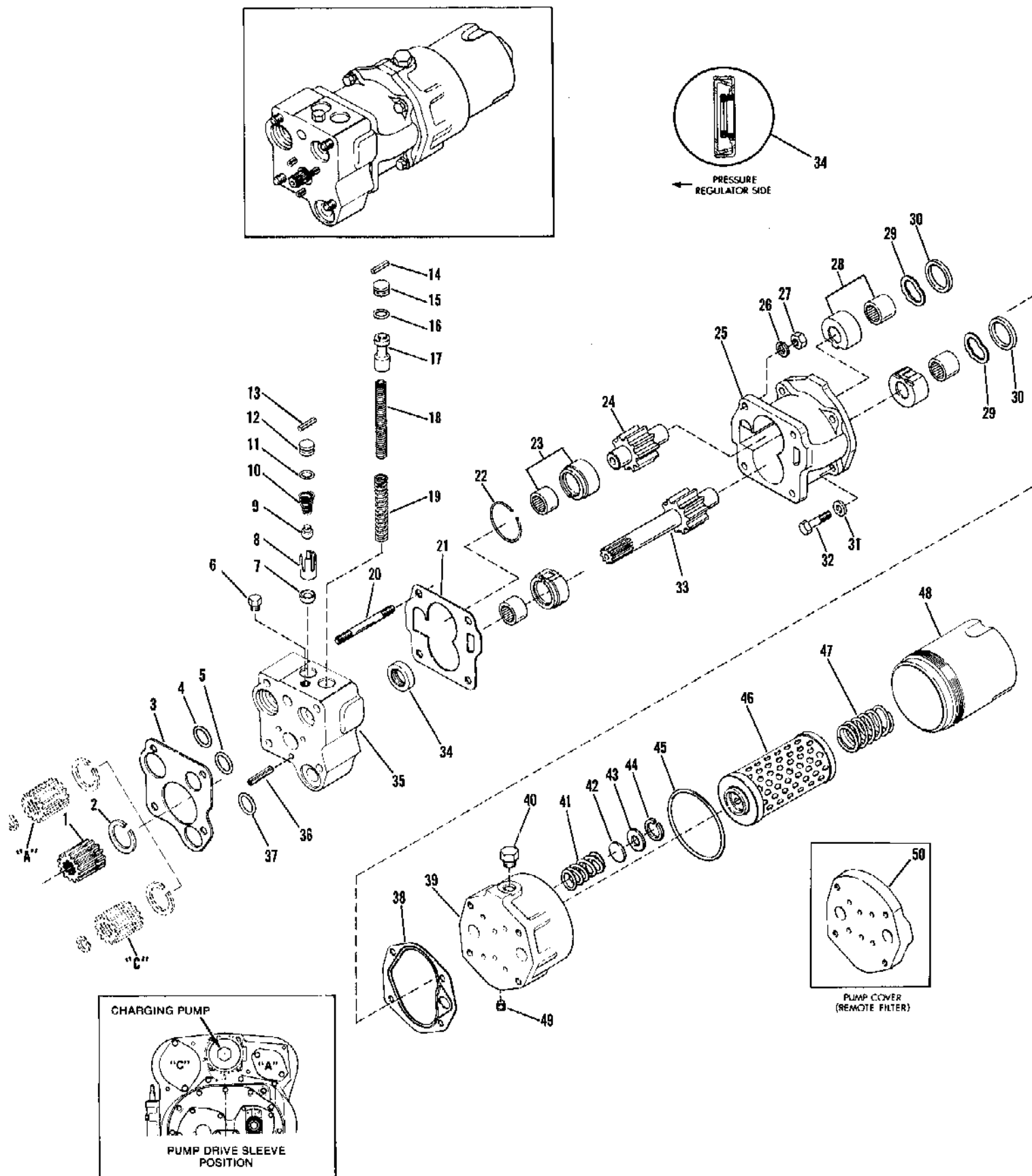


Figure E

PRESSURE REGULATOR VALVE, CHARGING PUMP & OIL FILTER GROUP

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Charging Pump Drive Sleeve.....	1	26	Valve to Housing Stud Lockwasher ...	4
2	Pump Sleeve Snap Ring	1	27	Valve to Housing Stud Nut	4
3	Valve to Housing Gasket.....	1	28	Thrust Plate & Bearing Assembly.....	2
4	Valve Body "O" Ring	1	29	Wave Spring.....	2
5	Valve Body "O" Ring	1	30	Pump Shaft Seal.....	2
6	Pipe Plug.....	1	31	Pump to Filter Adaptor Screw Lockwasher.....	4
7	Safety Valve Seat.....	1	32	Pump to Filter Adaptor Screw.....	4
8	Safety Valve Spacer.....	1	33	Pump Drive Shaft Assembly	1
9	Safety Valve Plunger	1	34	Pump Drive Shaft Oil Seal.....	1
10	Safety Valve Spring	1	35	Pressure Regulator Valve.....	1
11	Valve Stop "O" Ring	1	36	Valve Body Roll Pin	3
12	Valve Stop.....	1	37	Valve Body "O" Ring	1
13	Valve Stop Roll Pin	1	38	Pump to Filter Gasket	1
14	Valve Stop Roll Pin	1	39	Filter Adaptor	1
15	Valve Stop.....	1	40	Filter Adaptor Plug.....	1
16	Valve Stop "O" Ring	1	41	By-Pass Filter Disc Spring.....	1
17	Valve Piston	1	42	By-Pass Filter Disc.....	1
18	Valve Spring - Inner.....	1	43	By-Pass Filter Disc Seat	1
19	Valve Spring - Outer	1	44	Filter Seat Retainer Ring.....	1
20	Valve to Converter Housing Stud.....	4	45	Filter Housing "O" Ring.....	1
21	Valve Body to Pump Gasket	1	46	Oil Filter Element Assembly	1
22	Pump Body Snap Ring.....	1	47	Oil Filter Element Spring.....	1
23	Thrust Plate & Bearing Assembly.....	2	48	Filter Housing.....	1
24	Pump Driven Shaft Assembly	1	49	Pipe Plug.....	1
25	Charging Pump Housing	1	50	Optional Adaptor for Remote Filter ...	1

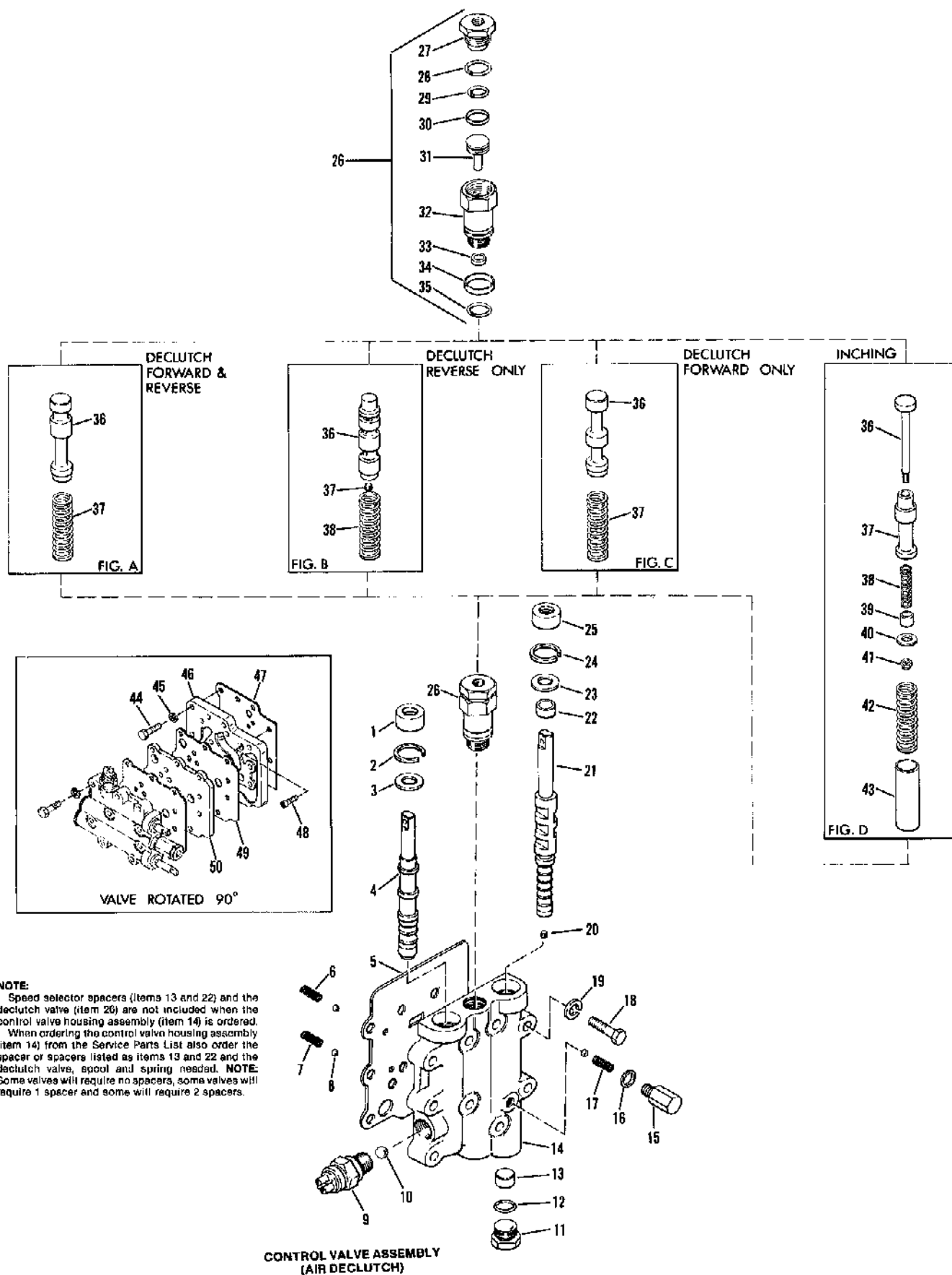


Figure F

CONTROL VALVE ASSEMBLY

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Oil Seal	1	22	Overshift Spacer (Not on all models)....	1
2	Oil Seal Retainer Ring	1	23	Oil Seal Retainer Washer	1
3	Oil Seal Retainer Washer	1	24	Oil Seal Retainer Ring	1
4	Forward & Reverse Valve Spool	1	25	Oil Seal	1
5	Control Valve Gasket	1	26	Piston Housing Assembly	1
6	Detent Spring	1	27	Stop Plug	1
7	Detent Spring	1	28	Plug "O" Ring	1
8	Detent Ball	3	29	Piston "O" Ring	1
9	Neutral Switch	1	30	Glyd Ring	1
10	Detent Ball	1	31	Piston	1
11	Valve Housing Plug	1	32	Piston Housing	1
12	Valve Housing Plug "O" Ring	1	33	Oil Seal	1
13	Overshift Spacer (Not on all models)....	1	34	Band Seal	1
14	Control Valve Housing	1	35	"O" Ring	1
15	Detent Spring Plug	1	Figures A-B-C & D are various declutch options.		
16	Detent Spring Plug Washer	1	44	Adaptor Screw	4
17	Detent Spring	1	45	Adaptor Screw Lockwasher	4
18	Valve to Adaptor Housing Screw	9	46	Valve Adaptor	1
19	Valve to Adaptor Housing Screw Lockwasher	9	47	Valve Adaptor Gasket	1
20	Speed Selector Spool Plug	1	48	Adaptor Screw	5
21	Speed Selector Spool	1	49	Adaptor to Plate Gasket	1
			50	Valve Adaptor Plate	1

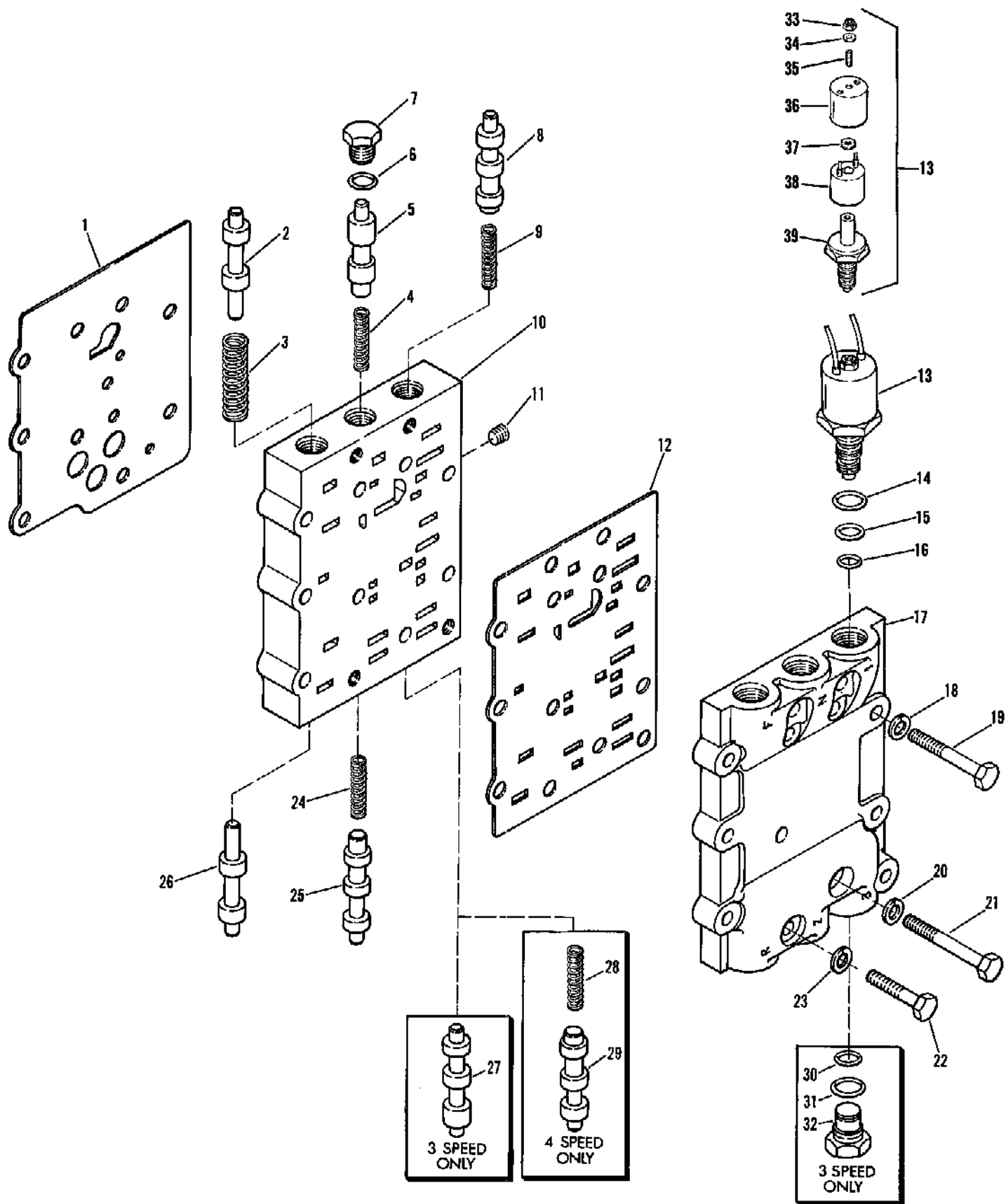
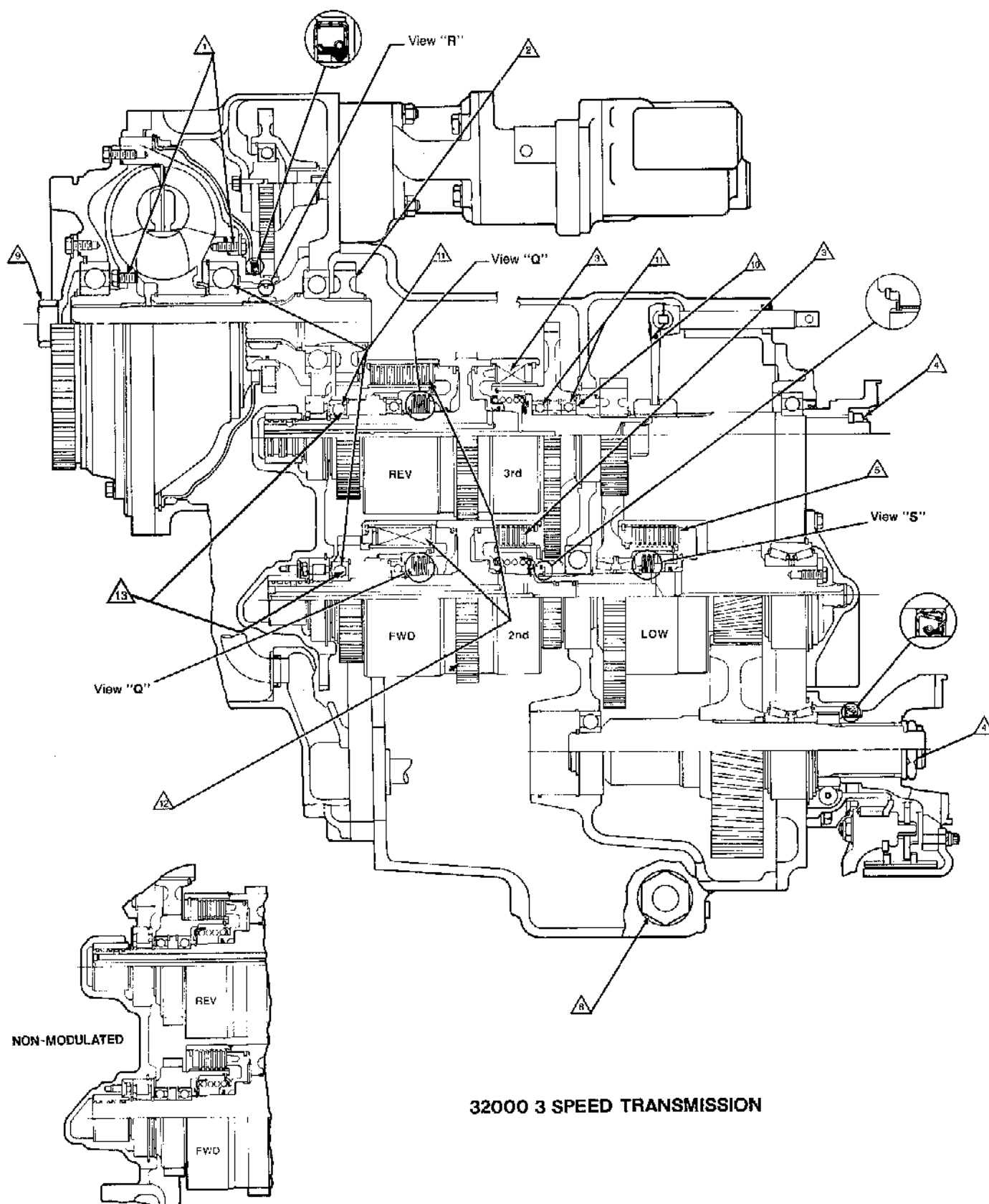


Figure G

SOLENOID CONTROL VALVE ASSEMBLY

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Valve Housing to Converter Housing Gasket.....	1	20	Valve Mounting Screw Lockwasher.....	4
2	Forward Spool	1	21	Valve Mounting Screw.....	4
3	Forward & Reverse Spool Spring...	1	22	Solenoid Housing to Control Valve Housing Screw.....	4
4	Range Spool Spring.....	1	23	Solenoid Housing to Control Valve Housing Screw Lockwasher	4
5	Range Spool.....	1	24	2nd Speed Spool Spring.....	1
6	Stop Plug "O" Ring	6	25	2nd Speed Spool.....	1
7	Control Valve Spool Stop Plug.....	6	26	Reverse Spool.....	1
8	Low Speed Spool.....	1	27	Speed Selector Spool	1
9	Low Speed Spool Spring.....	1	28	Speed Selector Spool Spring	1
10	Control Valve Assembly.....	1	29	Speed Selector Spool	1
11	Pipe Plug.....	1	30	Solenoid Plug "O" Ring.....	1
12	Solenoid Housing to Control Valve Housing Gasket	1	31	Solenoid Plug "O" Ring.....	1
13	Solenoid	*5	32	Solenoid Plug.....	1
14	"O" Ring	*5	33	Stop Nut	*5
15	"O" Ring	*5	34	Washer	*5
16	"O" Ring	*5	35	Set Screw	*5
17	Solenoid Control Housing.....	1	36	Coil Cover	*5
18	Valve Mounting Screw Lockwasher.....	5	37	Washer	*5
19	Valve Mounting Screw.....	5	38	Coil	*5
*Quantity depending on 3 or 4 speed. (4 speed Qty. 6)			39	Solenoid Sub Assembly.....	*5



32000 3 SPEED TRANSMISSION

Figure H

- ⚠ Impeller Hub and Turbine Hub Assembly with Backing Ring and Special Self Locking Screws.
1. Clean hub mounting surface and tapped holes with solvent. Dry thoroughly being certain tapped holes are dry & clean.
2. Install backing ring and special self locking screws.
Tighten screws 40 to 45 Lbs. Ft. [54,3-61,0 N·m]
Note: Assembly of hub must be complete within a fifteen minute period from start of screw installation. The special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced. The epoxy left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.
- ⚠ Gear to be assembled with long hub length to this side.
- ⚠ Two clutches, 6-outer steel plates, 6-inner friction plates. Assemble alternately, starting with outer steel plate.
- ⚠ See Elastic Stop Nut Torque Chart
- ⚠ Low clutch, 9-outer steel plates, 9-inner friction plates. Assemble alternately, starting with outer steel plate.
- ⚠ Tighten oil screen ass'y. 10 to 15 Lbs. Ft. [13,6-20,0 N·m]

- ⚠ Heat nose bushing to 200° F° (93°C) before ass'y. of bushing to cover.
- ⚠ Bearing shield out
- ⚠ Must be loose internal fit bearings, No. "3" etched on bearing.
- ⚠ (12 Plate Modulation) Two clutches, 12-outer steel plates, 12-inner friction plates. Assemble alternately, starting with outer steel plate.
- ⚠ Bearing shield in

Notes

- A. - Use Permatex & Crane Sealer only where specified.
B. - All lead in chamfers for oil seals, piston rings & "O" rings must be smooth & free from burrs. Inspect at ass'y.
C. - Lubricate all piston ring grooves & "O" rings with oil before ass'y.
D. - Apply very light coat of Permatex No. 2 to O.D. of all oil seals before ass'y.
E. - After assembly of parts using Permatex or Crane sealer, there must not be any free or excess material that could enter the oil circuit.
F. - Apply light coat of Crane Sealer to all pipe plugs.
G. - Apply a thin coating of grease between seal lips on lip type seals prior to ass'y.
H. - Apply light coat of Permatex No. 2 to all thru hole stud threads.

NOTE: The friction discs in the low clutch has a higher co-efficient rating than the friction discs in the other clutches, therefore the discs must not be mixed. The low clutch inner disc can be identified by an "X" stamped on one side of the inner teeth. The low clutch inner disc also has a strip of non-soluble yellow paint sprayed on the outer edge of the disc.

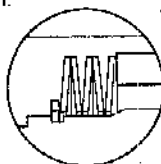
View "Q" 2 Places
Modulation only



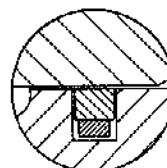
Forward & Reverse Clutch Return Springs. Concave side of first Belleville washer to be placed against clutch piston. Remaining six washers of each clutch to be stacked alternately reversed as shown.

Low Clutch Return Springs. Concave side of first Belleville washer to be placed against clutch piston. Remaining four washers to be stacked alternately reversed as shown.

View "S"



View "R"



Enlarged view of Piston Ring & Expander
Note: Expander gap to be approx. 180° from ring hook joint to aid ring assembly.

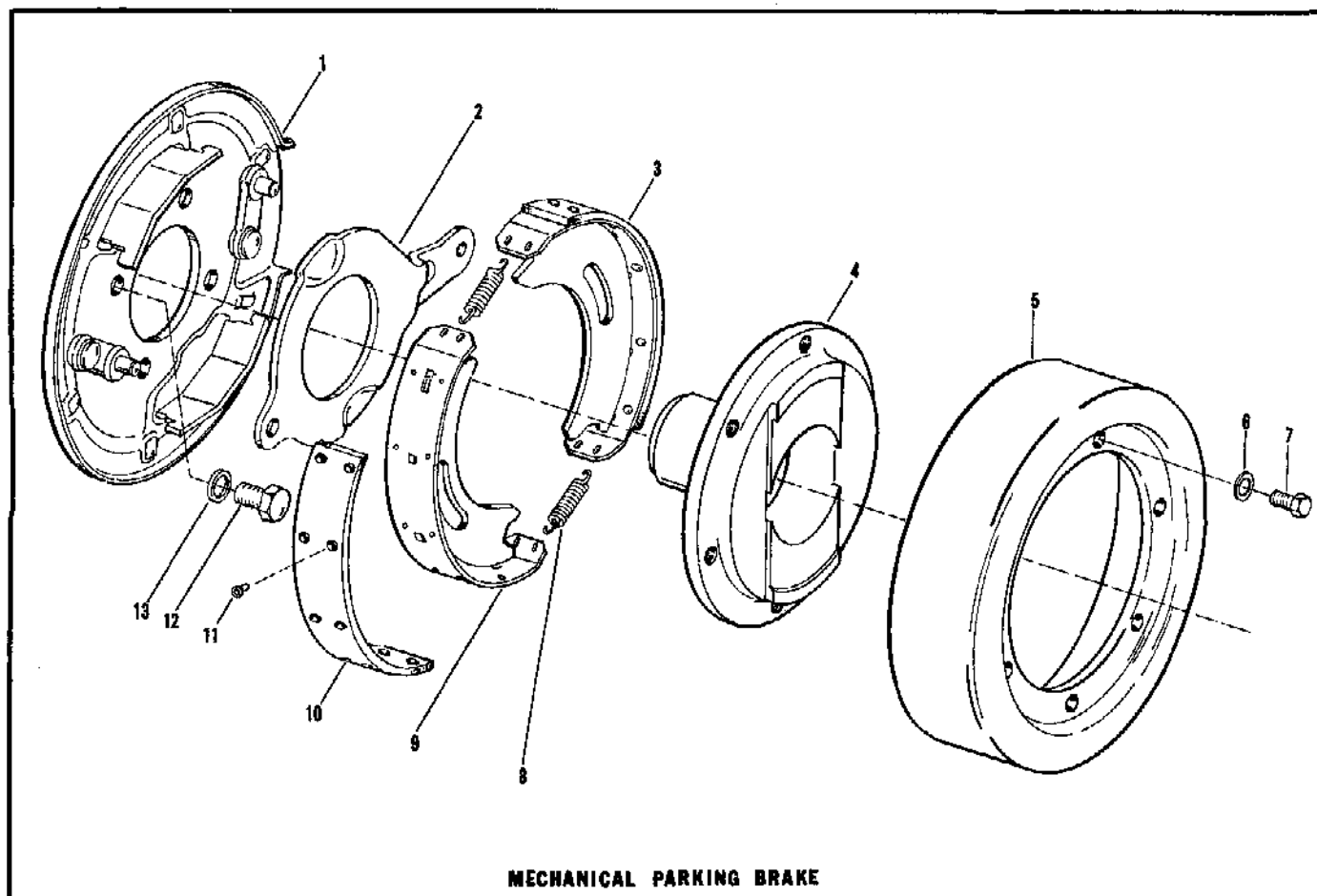
ELASTIC STOP NUT TORQUE

THREAD SIZE	LB.-FT.	[N·m]
1" - 20	150 - 200	[203,4 - 271,1]
1 1/4" - 18	200 - 250	[271,2 - 338,9]
1 1/2" - 18	300 - 350	[406,8 - 474,5]
1 3/4" - 12	400 - 450	[542,4 - 610,1]

NOTE: Metric dimensions shown in brackets [].

TORQUE SPECIFICATION FOR LUBRICATED OR PLATED SCREWS AND NUTS						
NOMINAL SIZE	GRADE 5			GRADE 8		
	FINE THREAD	COARSE THREAD		FINE THREAD	COARSE THREAD	
	lb-ft	lb-ft		lb-ft	lb-ft	
	[N·m]	[N·m]		[N·m]	[N·m]	
.2500	9-11	8-10		11-13	9-11	
	[12-15]	[11-14]		[15-18]	[12-15]	
.3125	16-20	12-16		28-32	28-30	
	[22-27]	[16-22]		[38-43]	[35-41]	
.3750	26-29	23-25		37-41	33-36	
	[35-39]	[31-34]		[50-58]	[45-49]	
.4375	41-45	37-41		58-64	52-57	
	[56-81]	[50-58]		[79-97]	[71-77]	
.5000	64-70	57-63		90-99	80-88	
	[87-95]	[77-85]		[122-134]	[108-119]	
.5625	91-100	82-90		128-141	115-127	
	[123-136]	[111-122]		[174-191]	[156-172]	
.6250	128-141	113-124		180-188	159-175	
	[174-191]	[153-168]		[224-288]	[218-237]	
.7500	223-245	200-220		315-347	282-310	
	[302-332]	[271-298]		[427-470]	[382-420]	

Figure H



MECHANICAL PARKING BRAKE

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Backing Plate Assembly.....	1	8	Return Spring	2
2	Actuating Lever	1	9	Brake Shoe (see item 3).....	
3	Brake Shoe and Lining	2	10	Brake Lining	2
4	Brake Flange	1	11	Rivet	20
5	Brake Drum	1	12	Backing Plate Screw	4
6	Brake Drum to Flange Screw Lockwasher	6	13	Backing Plate Screw Lockwasher	4
7	Brake Drum to Flange Screw	6			

Figure 1

MAINTENANCE AND SERVICE

The instructions contained herein cover the disassembly and reassembly of the transmission in a sequence that would normally be followed after the unit has been removed from the machine and is to be completely overhauled.

The photos shown in this text were taken of two different model transmissions. Although some of the photos may not be exactly like the transmission you are repairing, the procedures are identical. If a procedure is not identical, a clear photo and explanation will be shown. For R-Model (remote mounted) see R-Model section for front end removal, disassembly, reassembly and installation.

CAUTION: Cleanliness is of extreme importance and an absolute must in the repair and overhaul of this unit. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

DISASSEMBLY

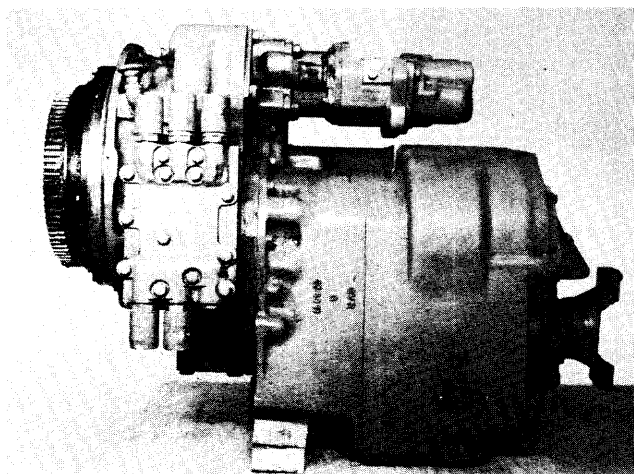


Figure 1

Side view of transmission.

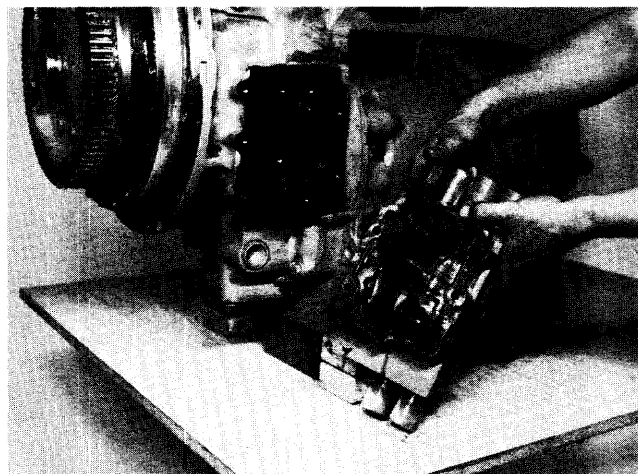


Figure 3

Remove valve assembly.

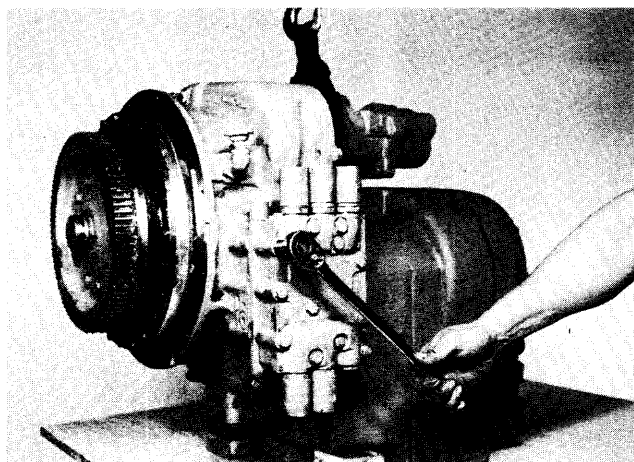


Figure 2

Remove control valve to housing bolts and washers. The valve shown is an electric shift with a modulator valve. **NOTE:** Control valves may vary from model to model.

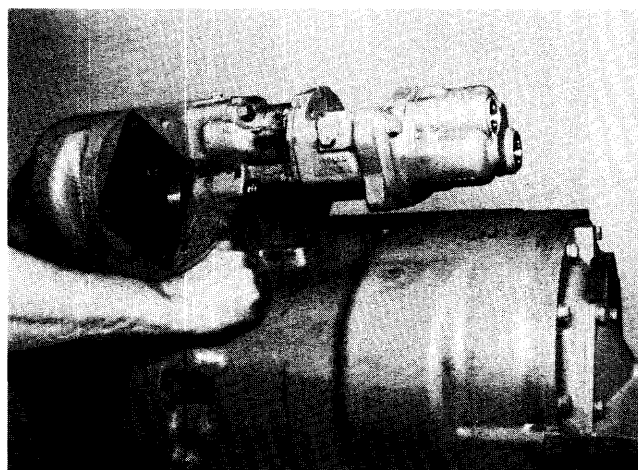


Figure 4

Remove charging pump to housing stud nuts. **NOTE:** Charging pumps may vary from model to model.

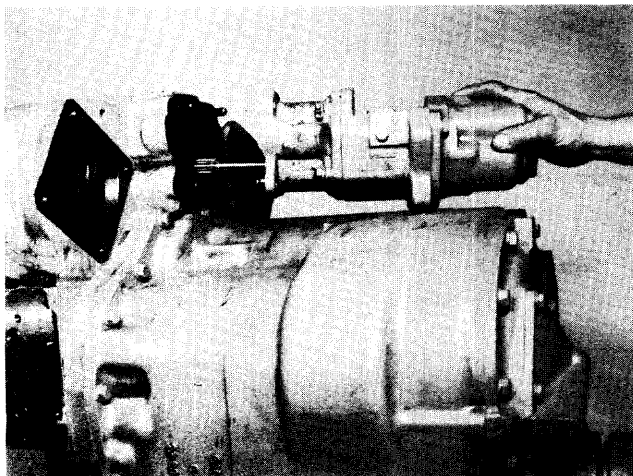


Figure 5
Remove charging pump assembly.

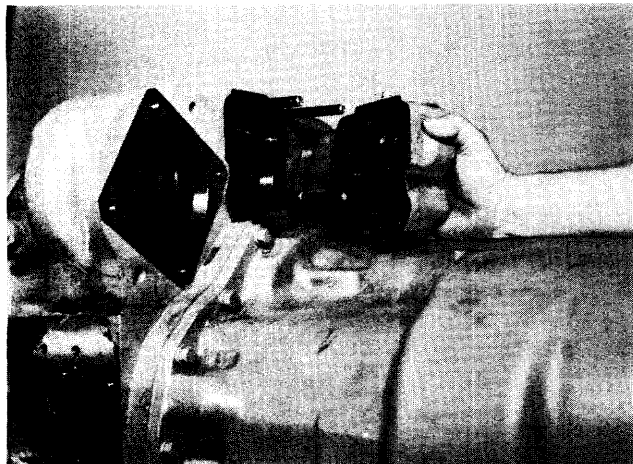


Figure 6
Remove pressure regulating valve assembly.

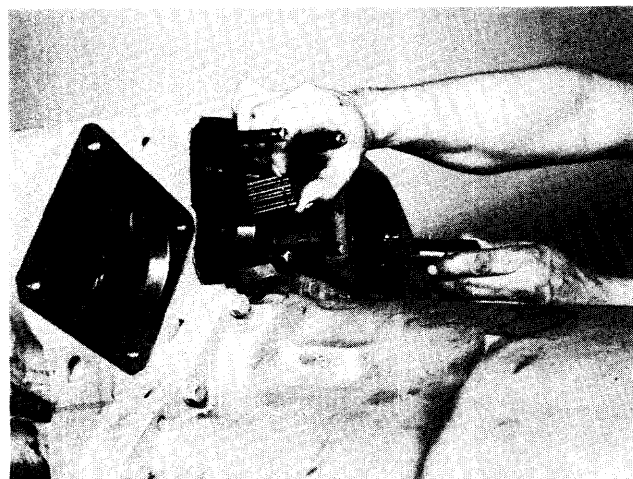


Figure 7
Remove pump drive sleeves.

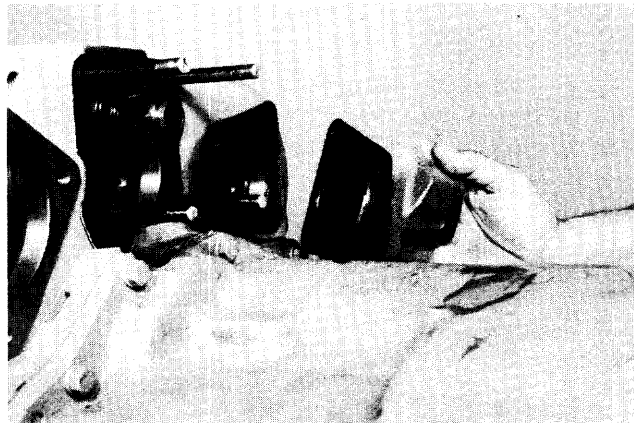


Figure 8
Remove pump adaptor bolts and pump adaptor. (Adaptors may vary.)

NOTE: The following converter disassembly was taken with a long drop transmission. Disassembly of the converter is identical on long and short drop transmissions.

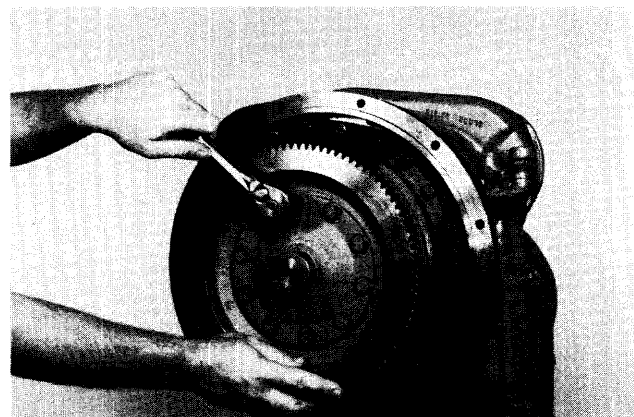


Figure 9
Remove impeller cover bearing cap bolts.

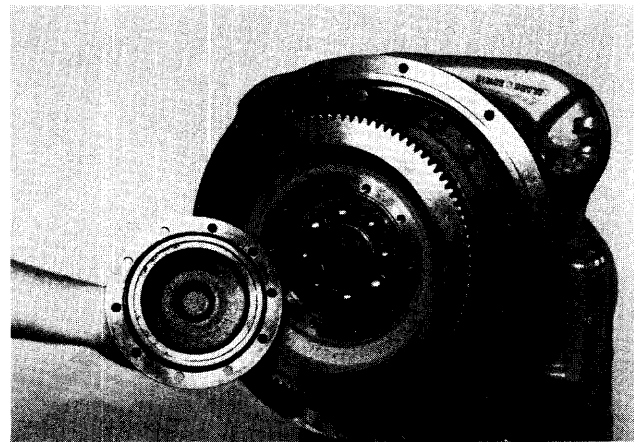


Figure 10
Remove impeller cover bearing cap.

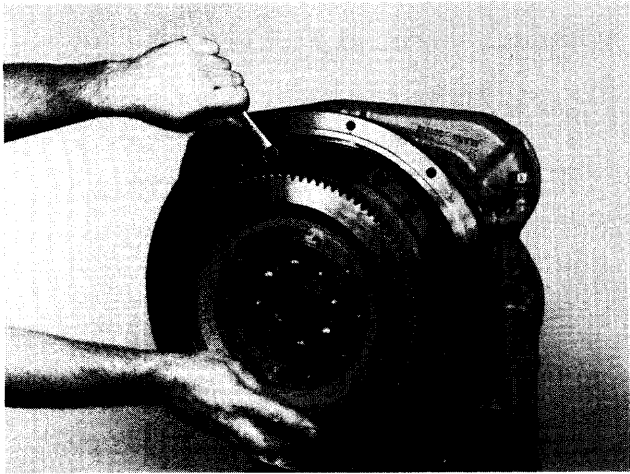


Figure 11

Remove impeller cover bolts.

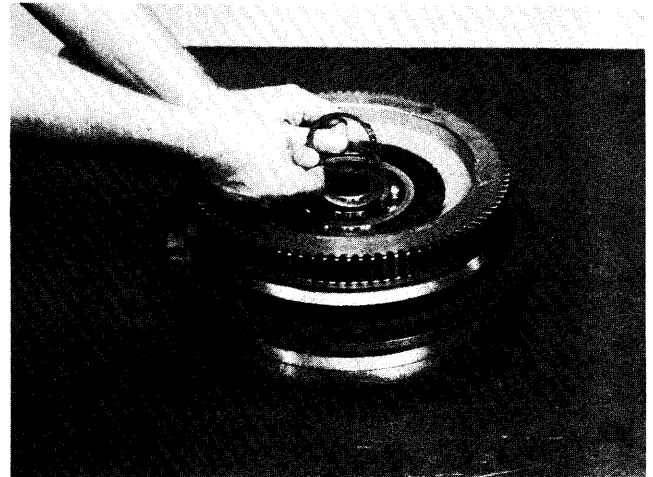


Figure 14

Remove impeller cover bearing snap ring and spacer. Separate impeller cover and turbine.

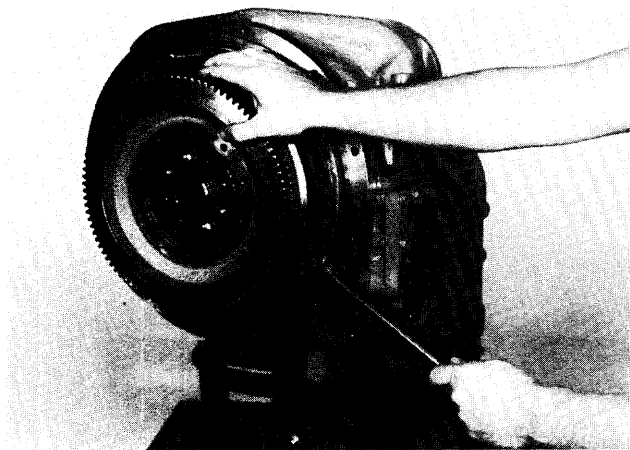


Figure 12

Install aligning stud. Use pry slots to remove cover.

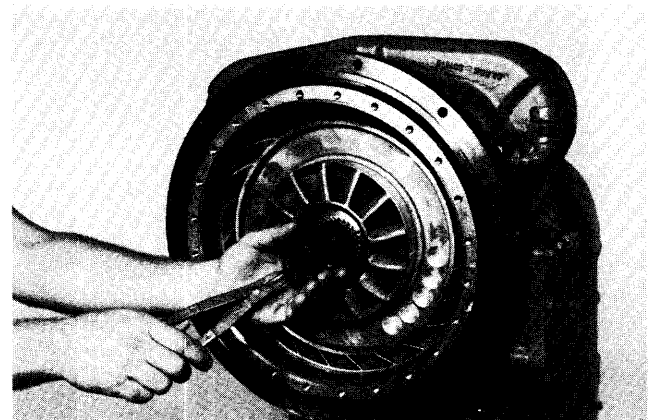


Figure 15

Remove reaction member retainer ring.

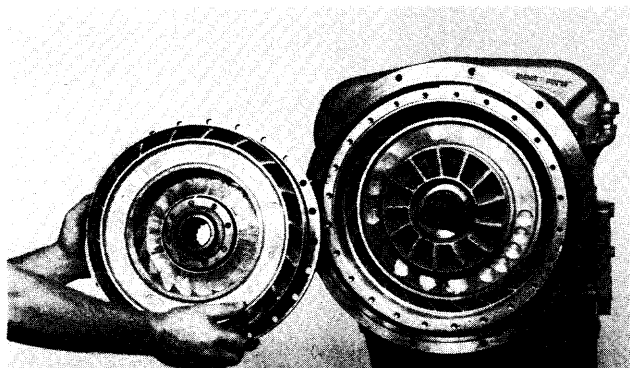


Figure 13

Remove impeller cover and turbine as an assembly.

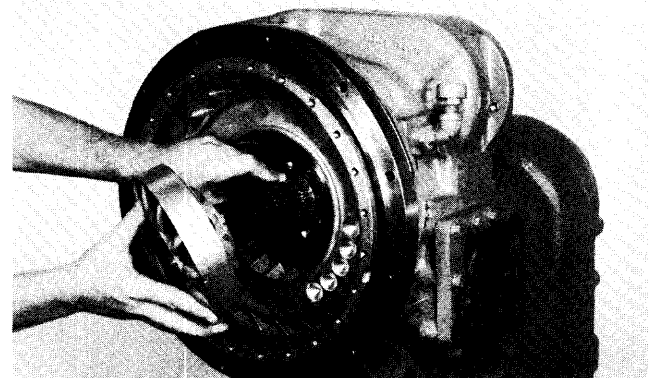


Figure 16

Remove reaction member and spacer.

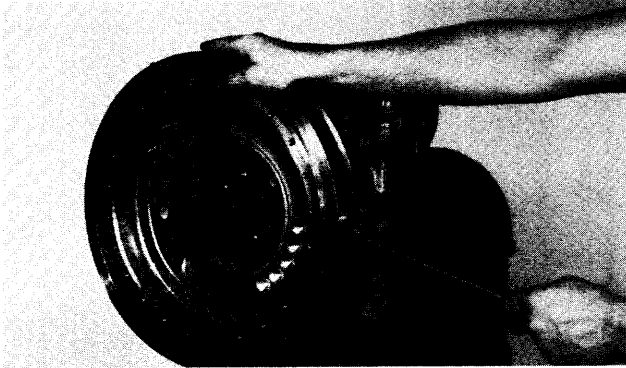


Figure 17
Remove converter housing to engine housing spacer ring.

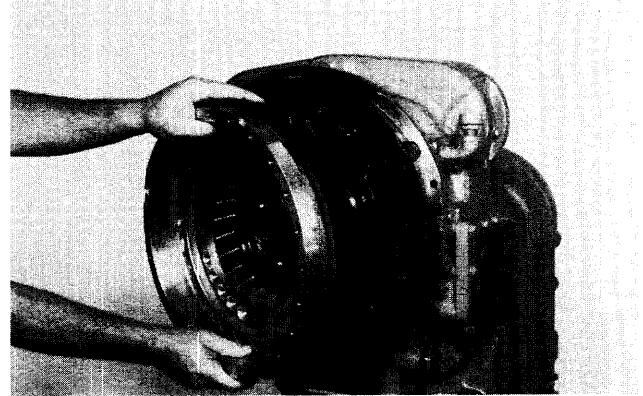


Figure 20
Remove impeller assembly.

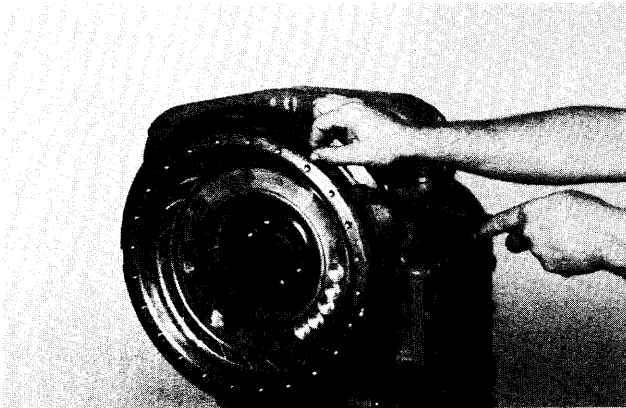


Figure 18
Remove oil baffle retainer ring.

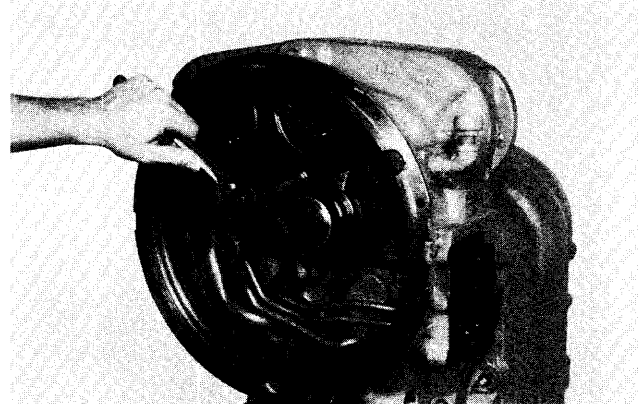


Figure 21
Remove stator support to housing bolts.

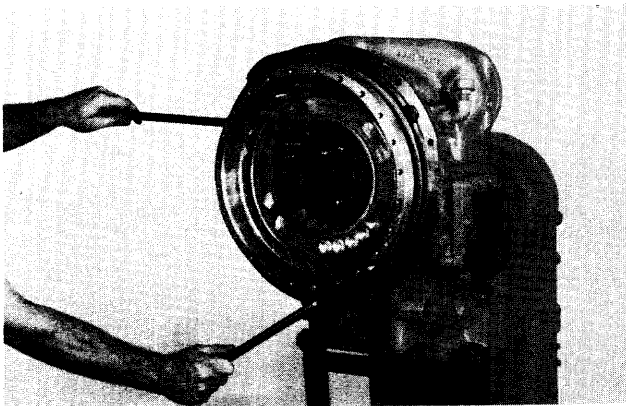


Figure 19
Using pry slots in converter housing, pry oil baffle and impeller from housing. **NOTE:** Impeller, oil baffle and impeller hub gear are removed as an assembly.

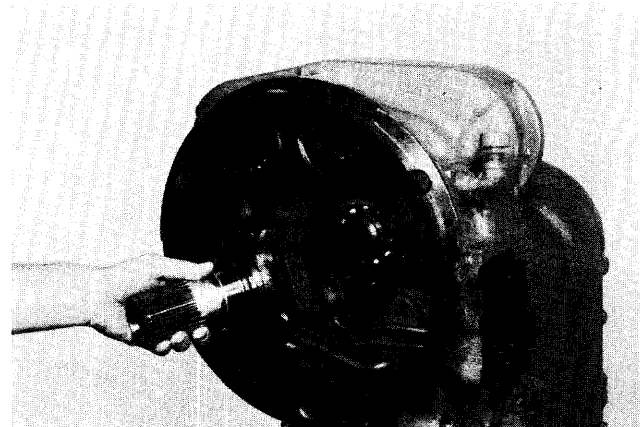


Figure 22
Remove stator support. **NOTE:** Support must be turned to clear pump drive gear.

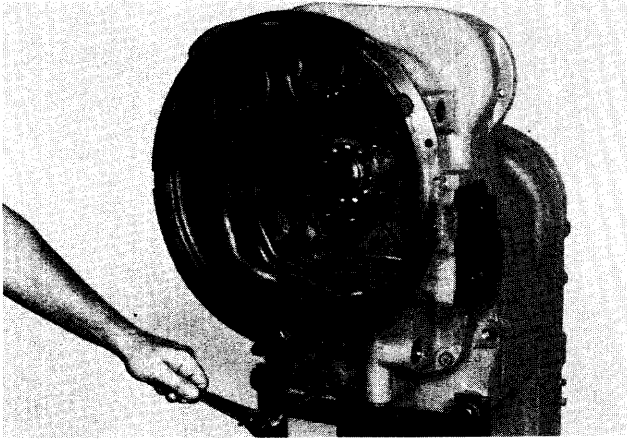


Figure 23

Remove converter housing to transmission housing bolts.

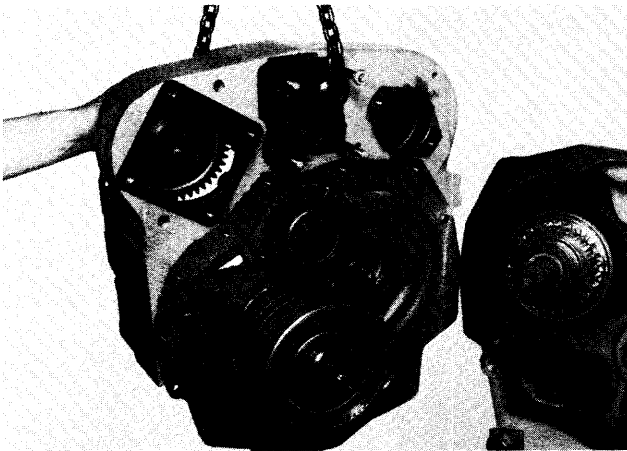


Figure 24

Support converter housing with chain fall and separate from transmission housing.

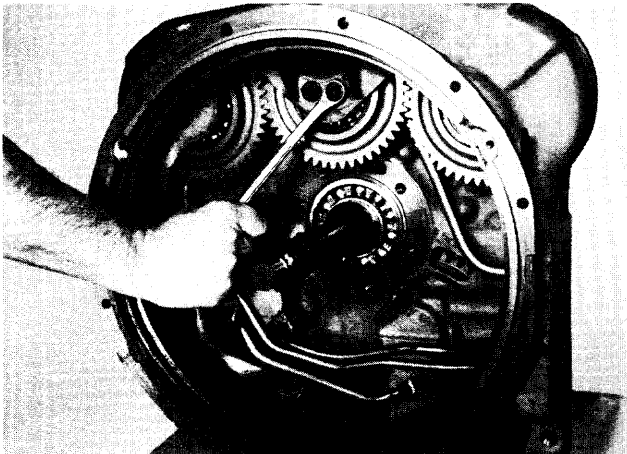


Figure 25

Remove pump drive gear bearing support bolts.

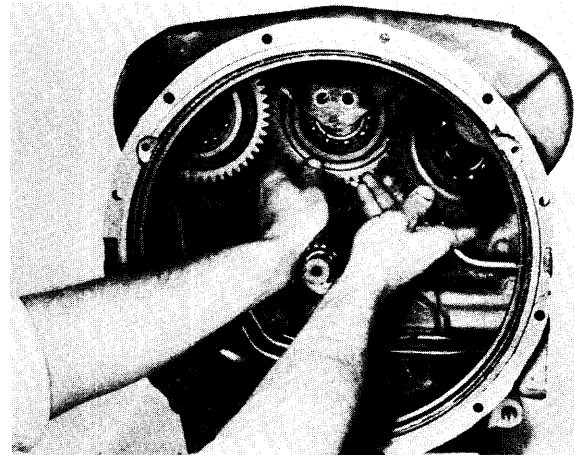


Figure 26

Move center gear toward the rear of converter housing. Remove pump drive gear on the right.

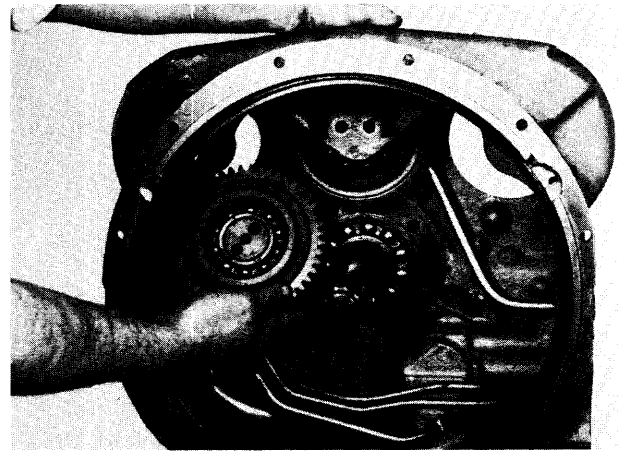


Figure 27

Remove pump drive gear on the left.

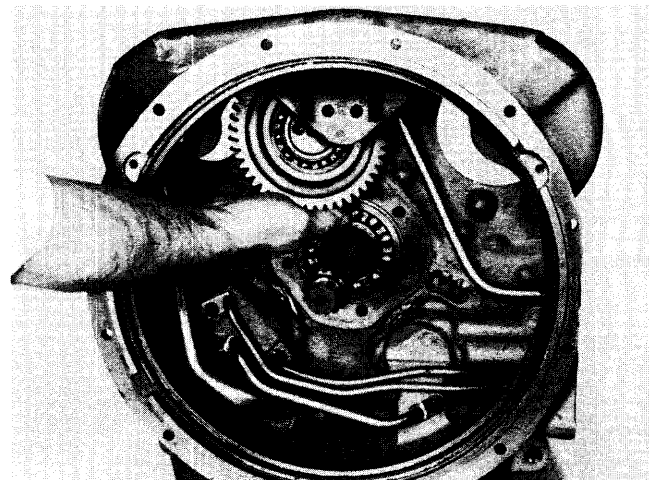


Figure 28

Remove center pump drive gear.

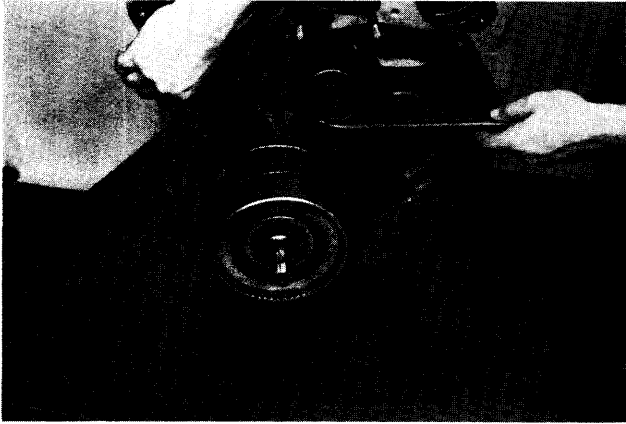


Figure 29

Use a spreading type snap ring pliers to spread the ears on forward clutch front bearing retainer ring. Remove forward clutch with pry bar.

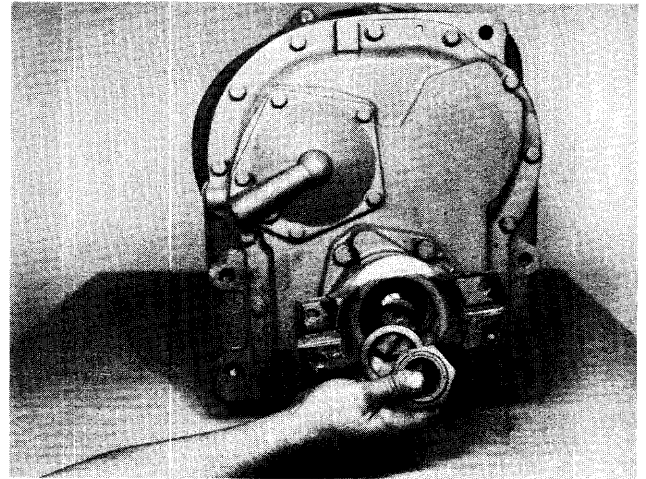


Figure 32

Remove output flange nut, washer and "O" ring.

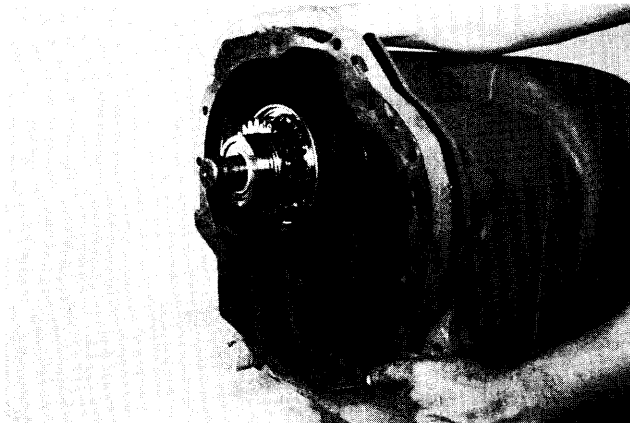


Figure 30

Remove converter to transmission spacer. (Used with 12 plate modulated clutches only.)

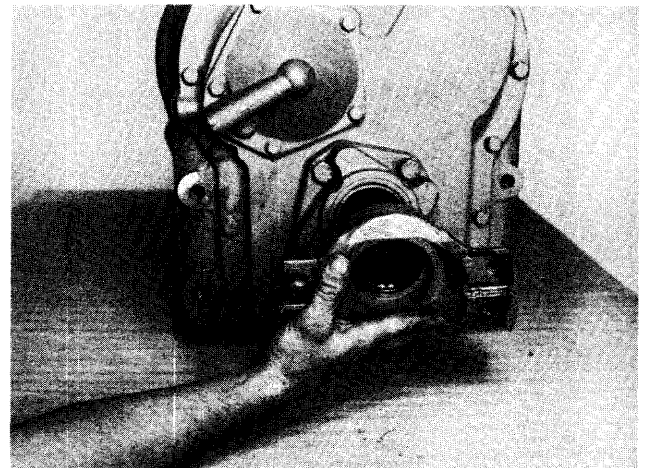


Figure 33

Remove output flange.

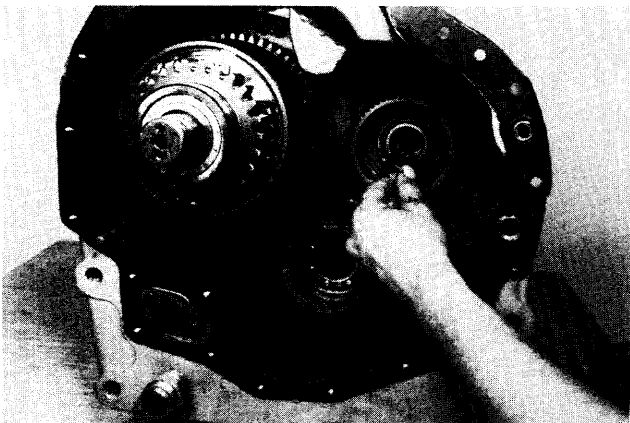


Figure 31

Remove 2nd clutch pilot bearing.

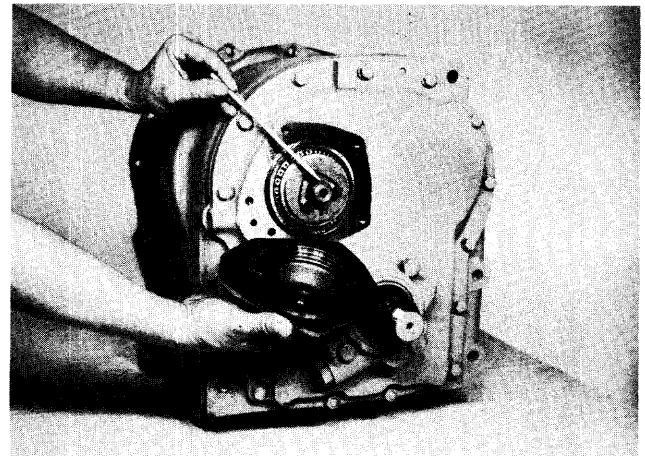


Figure 34

Remove low clutch bearing cap. Note oil sealing ring.

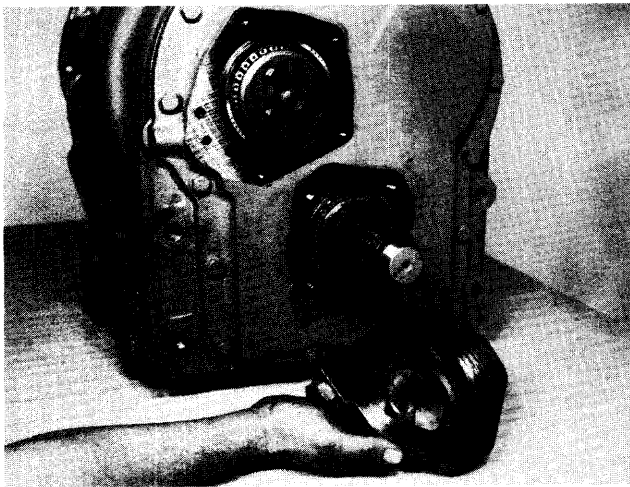


Figure 35
Remove output shaft bearing cap.

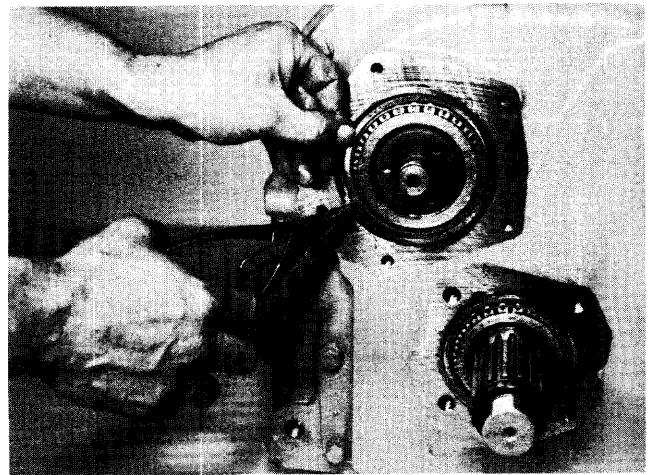


Figure 38
Remove output shaft and low clutch rear bearing locating ring.

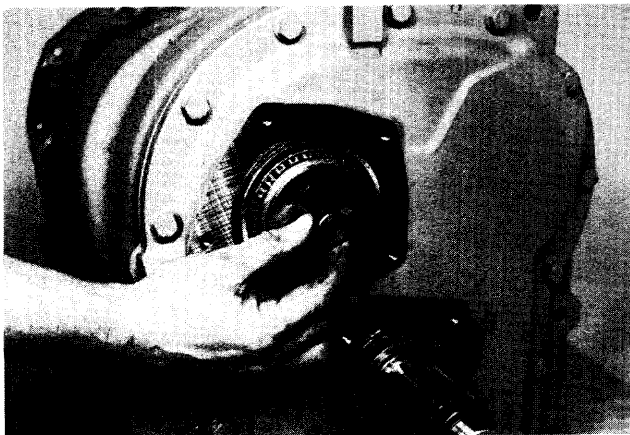


Figure 36
Cut and remove low clutch rear bearing retainer plate bolt lockwire. Remove low clutch shaft oil sealing ring.

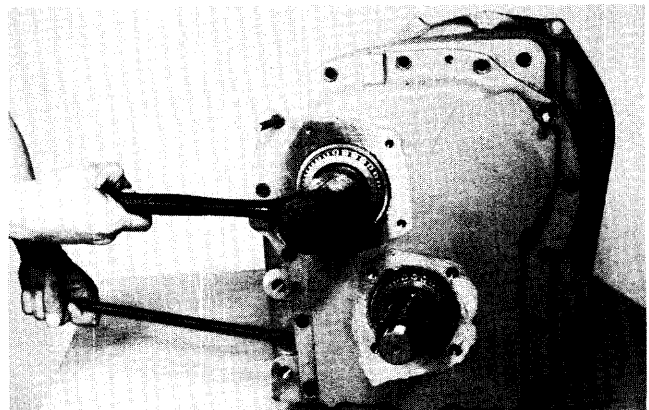


Figure 39
Remove rear cover bolts. Using pry slots provided, pry cover from transmission housing tapping on low clutch and output shaft to allow cover to be removed without shaft binding. **NOTE:** The use of alignment studs will facilitate cover removal.

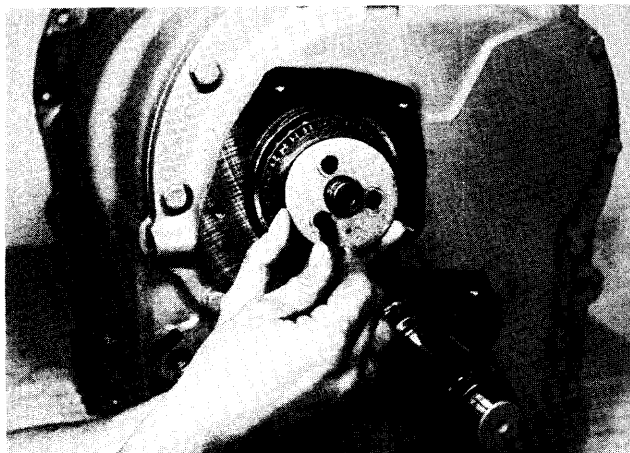


Figure 37
Remove retainer plate bolts and plate.

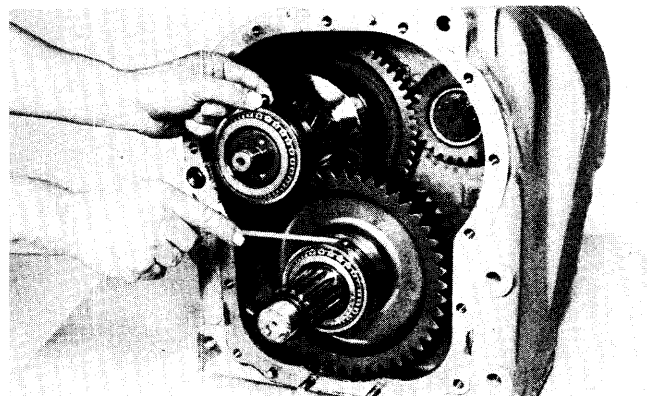


Figure 40
Remove bearing lock balls.

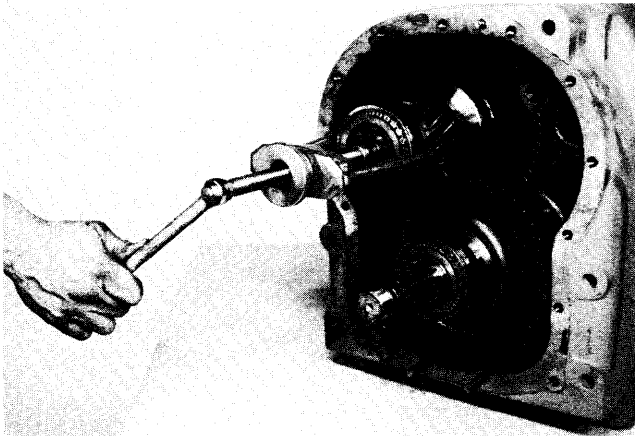


Figure 41

Remove low clutch double bearing cup, outer cone bearing and spacer.

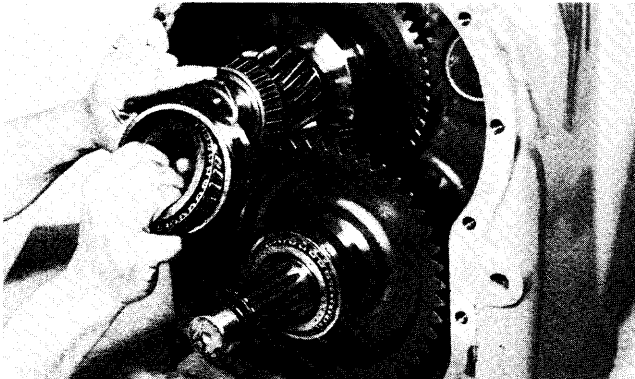


Figure 42

CAUTION: Outer cone bearing, double bearing cup, spacer and inner cone bearing are replaced as a set only.

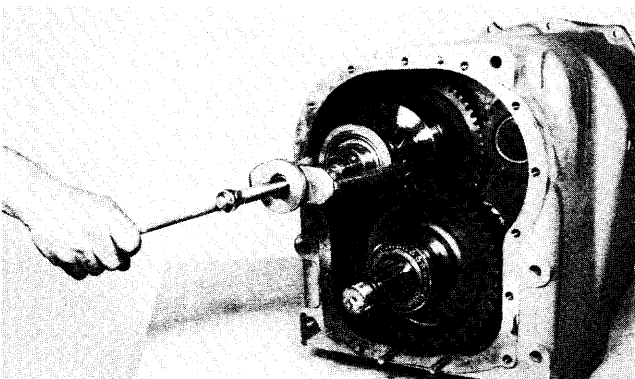


Figure 43

Remove low clutch inner bearing cone. **NOTE:** To remove the inner cone bearing without damage, a special bearing puller must be made (see diagram Fig. 43-A) or the outer cage and rollers may be pulled from the bearing inner race and the inner race can be removed after the low clutch assembly has been removed from the transmission. See caution in Figure 42.

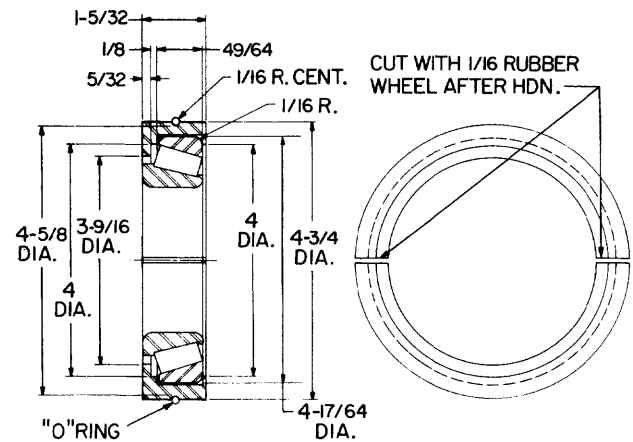


Figure 43-A

A timken bearing cup, No. 29520 must be used with the above bearing puller.

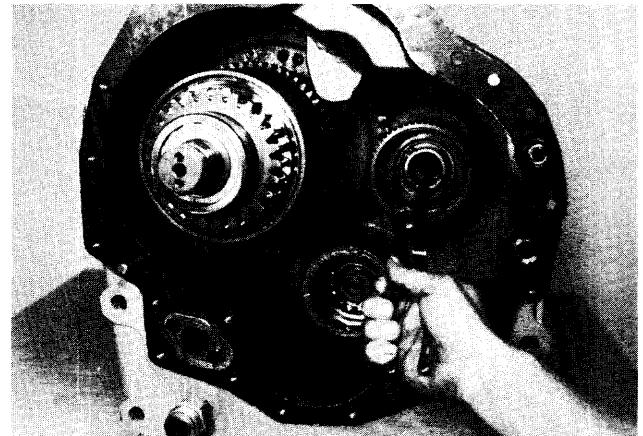


Figure 44

Remove 2nd gear ring retainer snap ring.

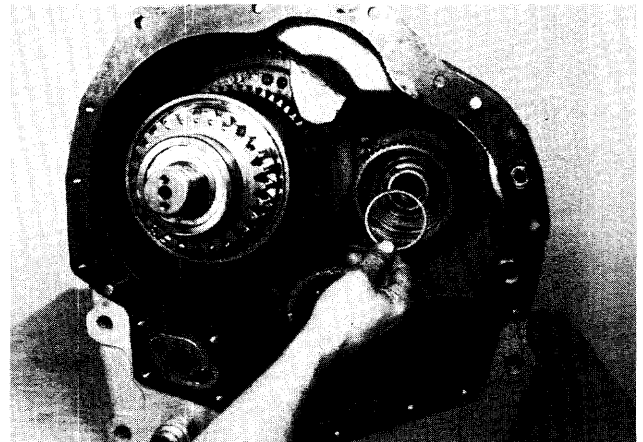


Figure 45

Remove 2nd gear retainer ring retainer.

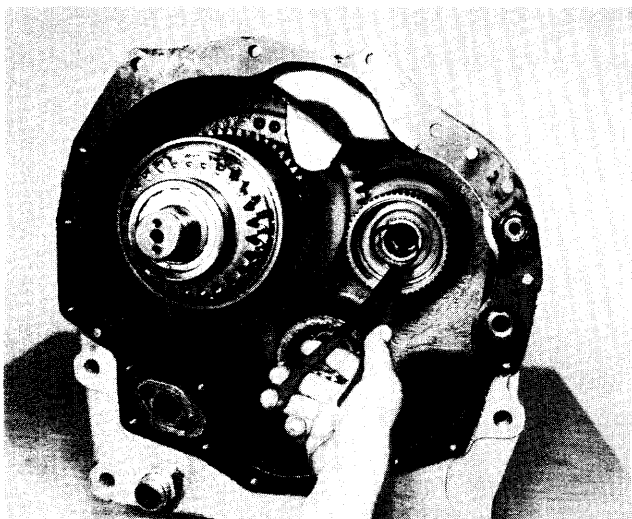


Figure 46

Remove 2nd gear retainer ring.

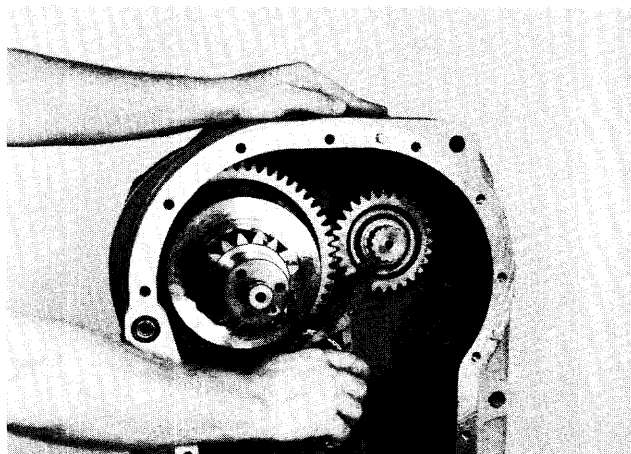


Figure 49

Remove low speed drive gear retainer ring and drive gear.

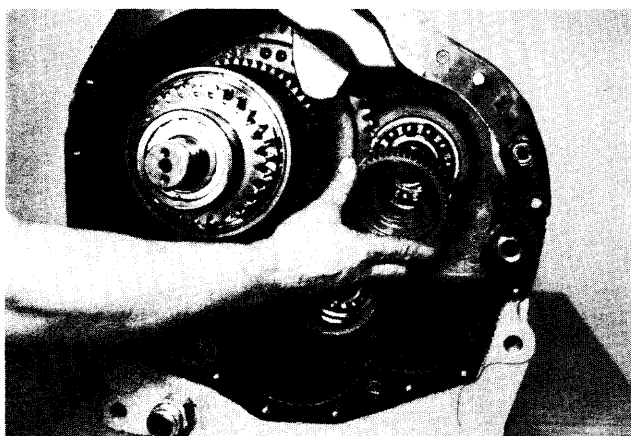


Figure 47

Remove 2nd gear. **NOTE:** On the 4 speed transmission there is a bearing end plate between the 2nd gear and bearing.

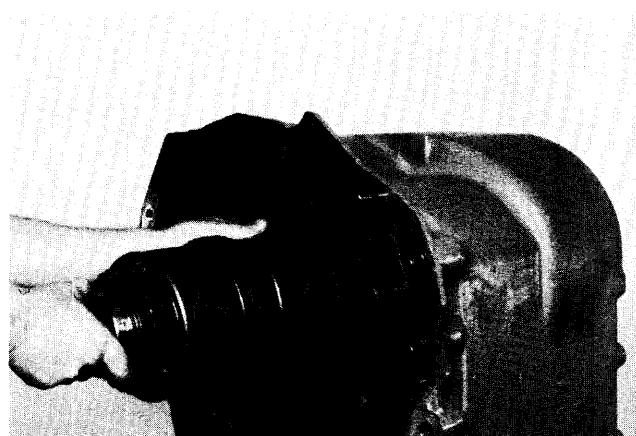


Figure 50

Remove reverse and 3rd clutch assembly.

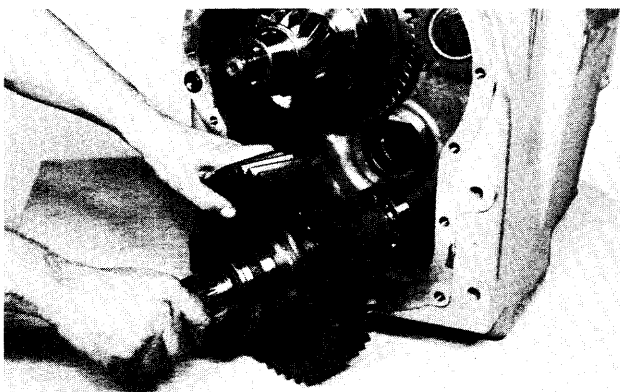


Figure 48

Remove output shaft assembly. (3 speed output shaft shown.)



Figure 51

Remove low clutch assembly.



Figure 52

Remove impeller hub gear retainer ring.

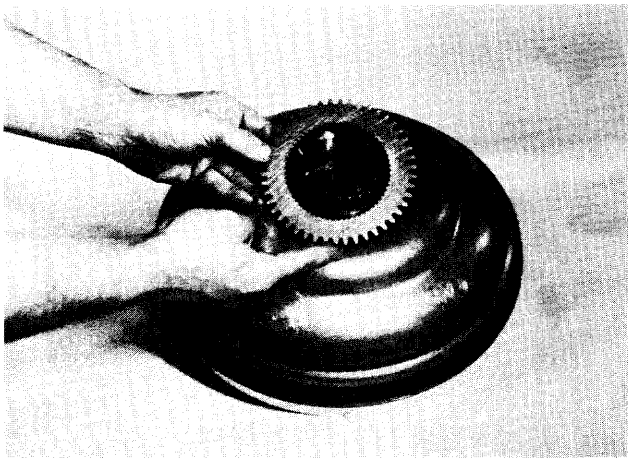


Figure 53

Remove impeller hub gear.

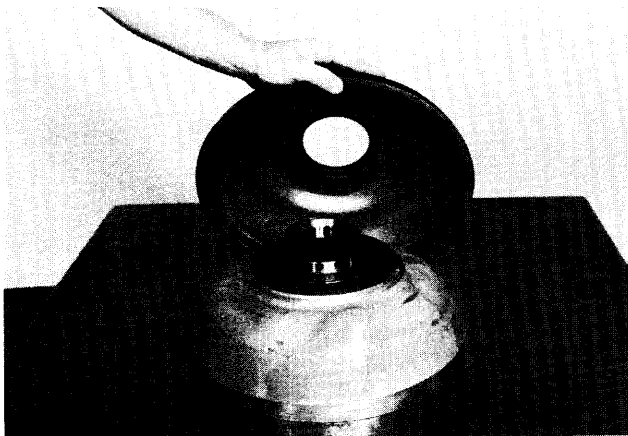


Figure 54

Lift oil baffle and oil seal assembly from impeller.

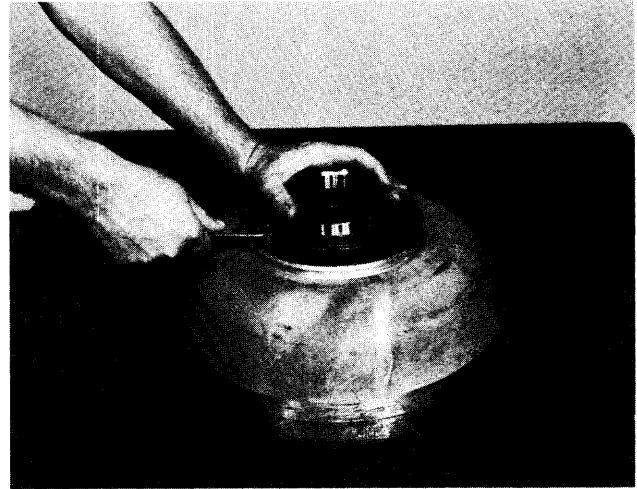


Figure 55

Remove impeller to hub bolts.

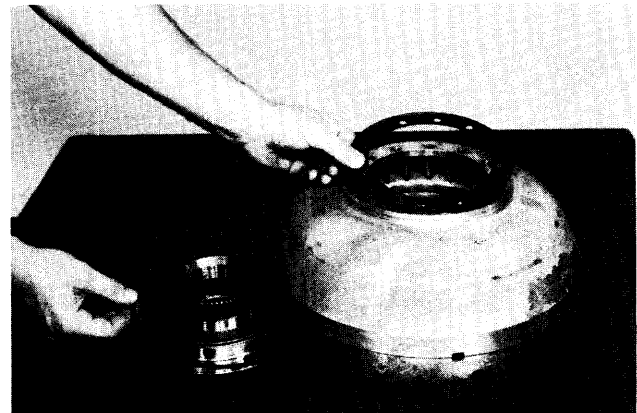


Figure 56

Remove impeller hub, "O" ring and impeller hub screw backing ring.

CLUTCH DISASSEMBLY

Figure 56

NOTE: Each disc spring assembly is made up of selected springs to precisely match each part within this assembly. Failure to replace all piston return springs can result in unequal deflection within the spring pack. The result of this imbalance may adversely affect overall life of springs.

The disc spring packs are to be used as complete assemblies and care should be taken not to intermix the individual disc springs with disc springs in another clutch or disc spring pack.

NOTE: DO NOT MIX THE FRICTION DISC IN THE LOW CLUTCH WITH THE FRICTION DISCS OF ANY OF THE OTHER CLUTCHES. (SEE NOTE FOLLOWING FIGURE 104).

LOW CLUTCH DISASSEMBLY

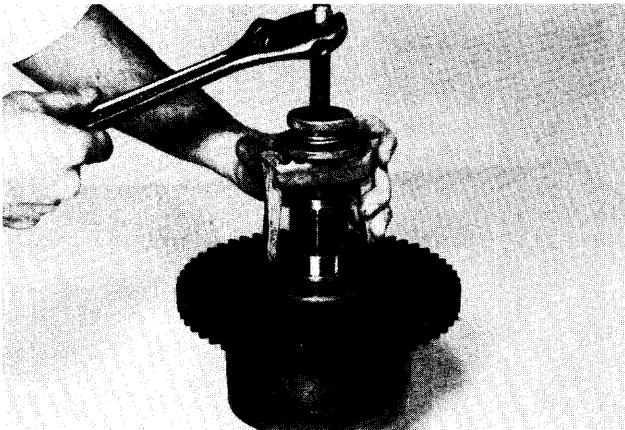


Figure 57

Remove low clutch shaft front bearing race.

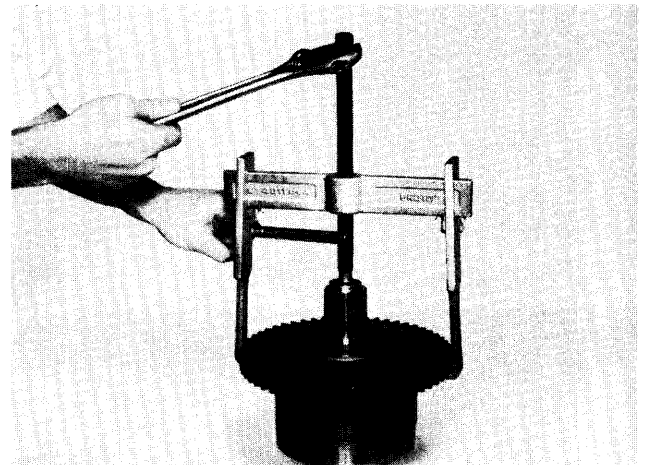


Figure 60

Remove low speed gear and outer taper bearing. Remove low clutch taper bearing spacer.

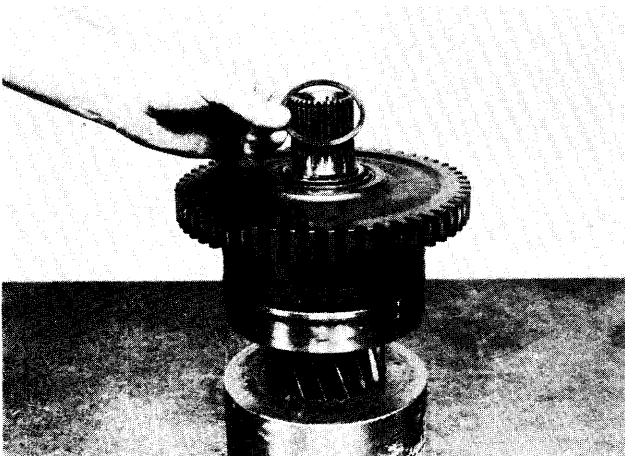


Figure 58

Remove low speed gear taper bearing retainer ring retainer.

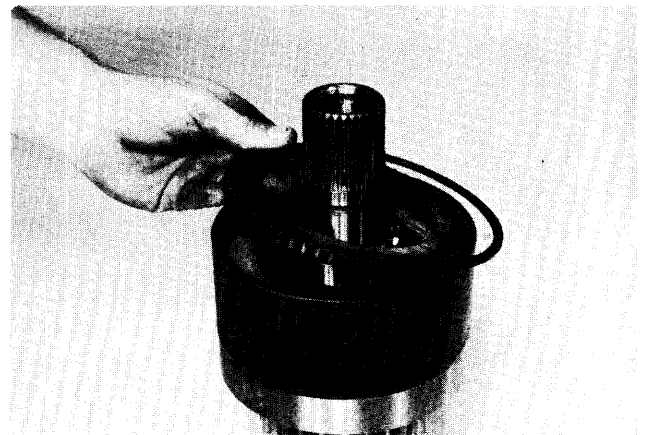


Figure 61

Remove clutch end plate retainer ring. Remove clutch end plate and inner and outer clutch discs.

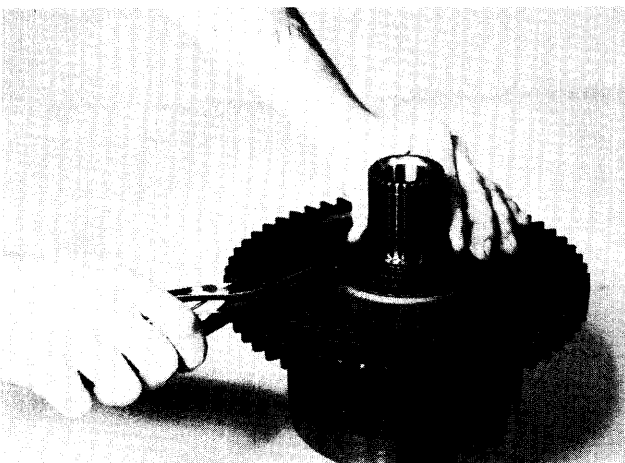


Figure 59

Remove low speed gear taper bearing retainer ring.

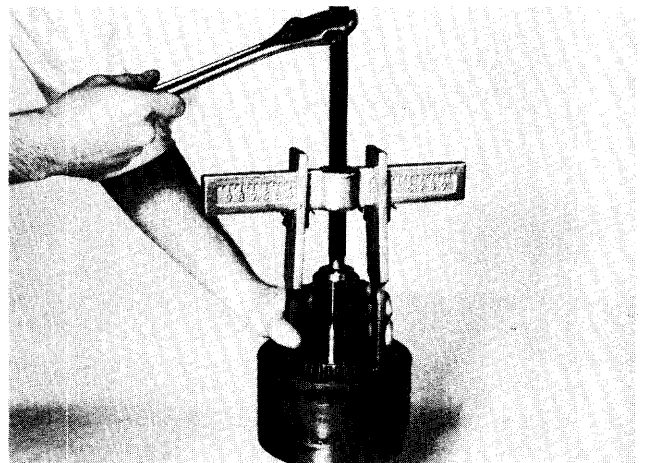


Figure 62

Remove low gear inner taper bearing.

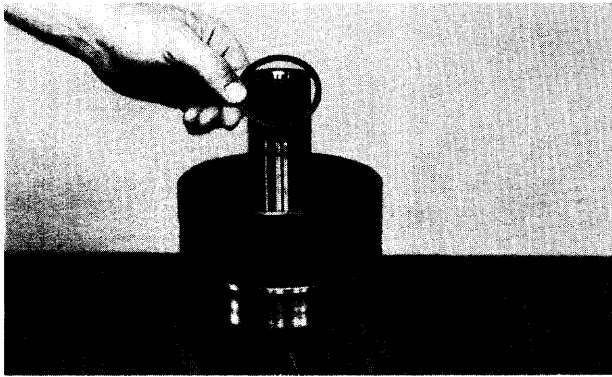


Figure 63

Remove snap ring, ring retainer.

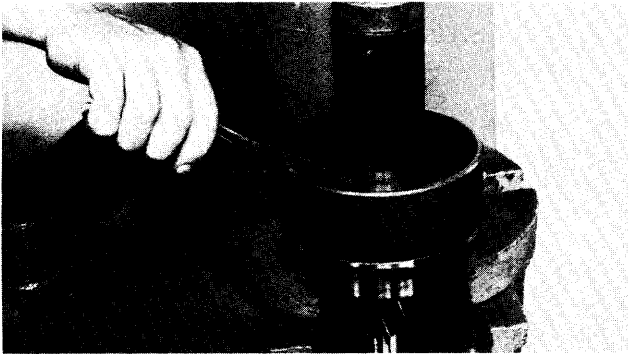


Figure 64

Remove clutch piston return disc spring retainer ring. A sleeve with a portion removed is recommended for removing the clutch piston return spring washers and retainer ring. Sleeve shown is a common pipe, with a 1-1/2 x 1 [39,0 x 26,0mm] opening. The pipe is 6 x 3-1/4 x 2-3/4 [155,0 x 85,0 x 78,0mm]. Compress disc springs washer. Through opening, remove retainer ring. Release tension on washers. Remove spring retainer ring.



Figure 65

Remove disc springs and spacer. Turn clutch over and tap clutch shaft on a block of wood to remove clutch piston. **NOTE:** Disc springs in the low clutch are different than disc springs in the forward and reverse clutch. Do not mix low clutch springs with forward and reverse springs. See page 40 for spring identification.

FORWARD AND 2ND CLUTCH DISASSEMBLY

(Forward being disassembled)

Forward and 2nd clutch and reverse and 3rd clutch disassemble and reassemble the same except forward and reverse clutches use disc springs for the piston return and the 2nd and 3rd clutches use a spring for the piston return. **NOTE:** If forward and reverse clutches are non-modulated, they will also use a spring for piston return instead of disc springs.



Figure 66

Remove clutch shaft piston rings and expander springs. See page 67 for proper piston ring and expander spring installation.

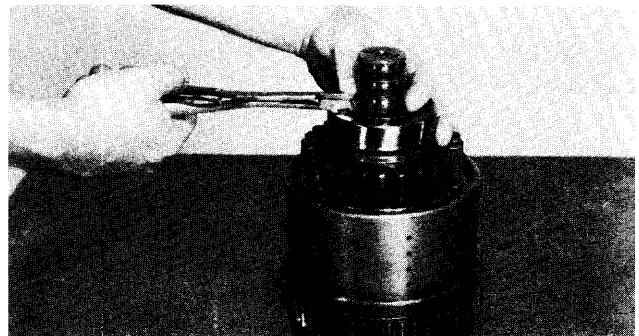


Figure 67

Remove front bearing retainer ring.

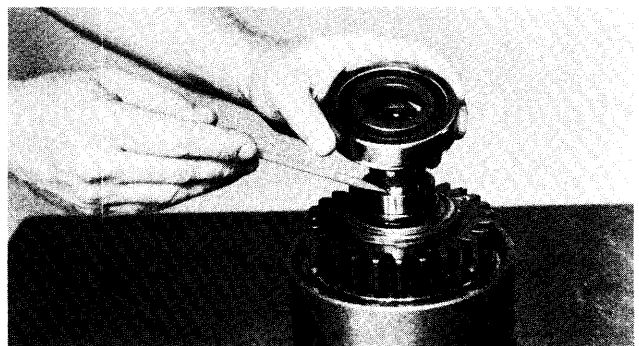


Figure 68

Remove spacer and bearing. **Caution:** Do not lose lock ball.

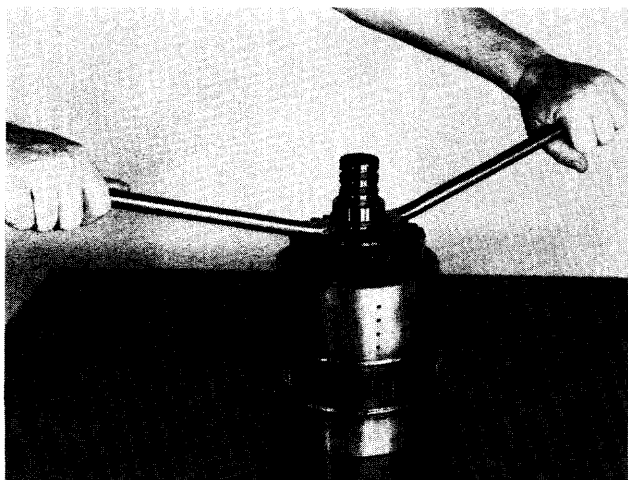


Figure 69

Pry front bearing inner race from shaft. **Caution:** Do not damage bearing roller surface.

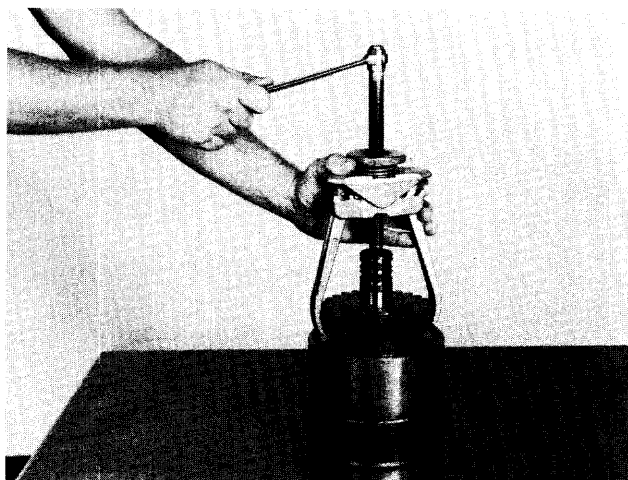


Figure 72

Remove clutch driven gear and outer bearing.

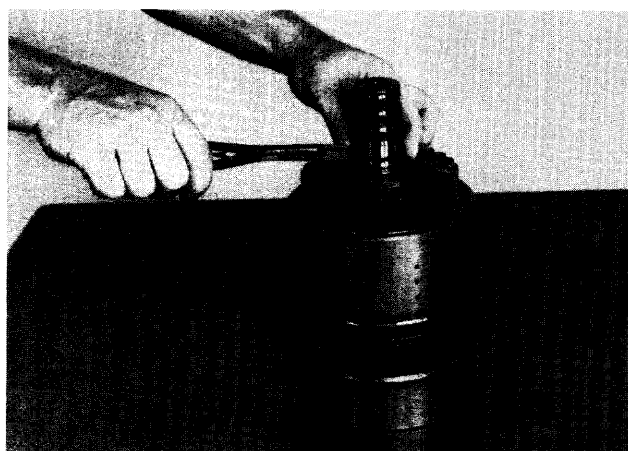


Figure 70

Remove front bearing locating ring.

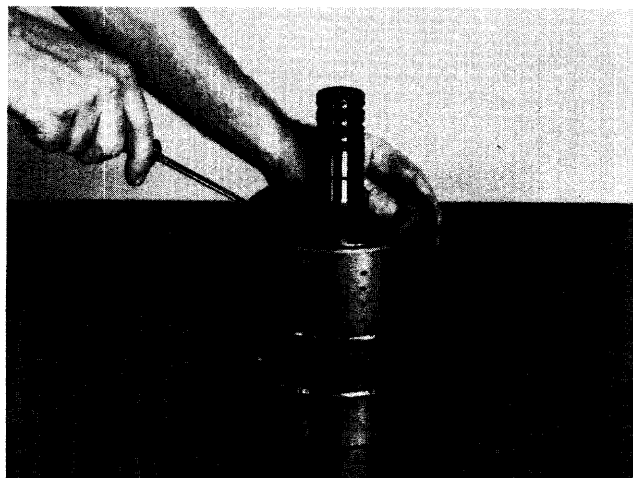


Figure 73

Remove end plate retainer ring.

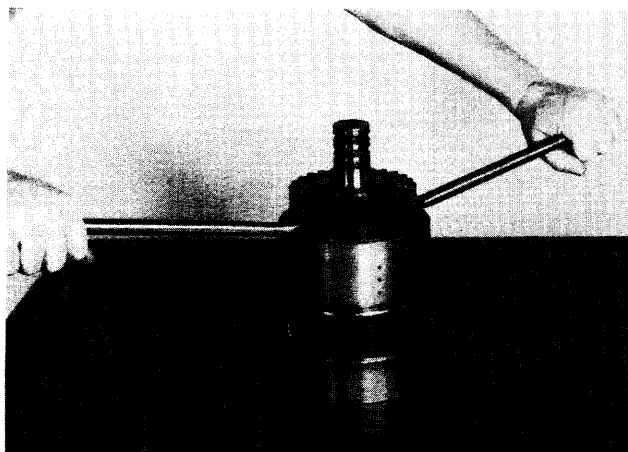


Figure 71

Pry gear up to accommodate gear puller.



Figure 74

Remove end plate.

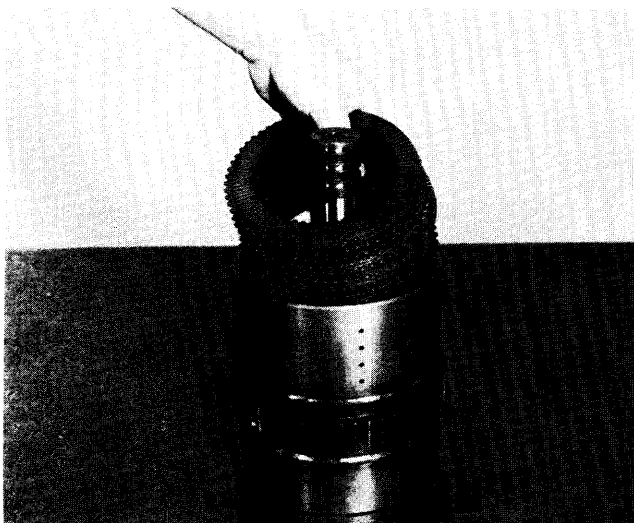


Figure 75

Remove inner and outer clutch discs.

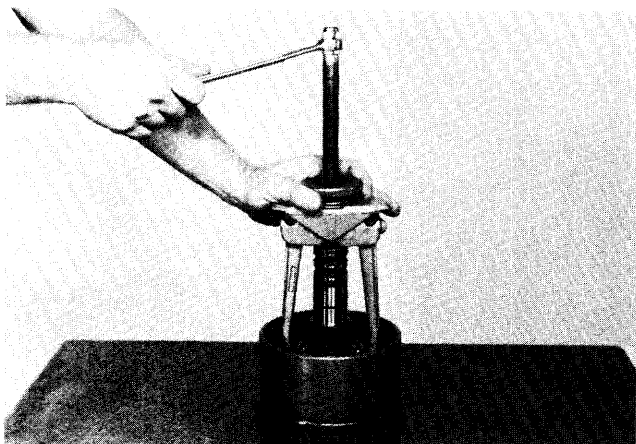


Figure 76

Remove inner bearing.

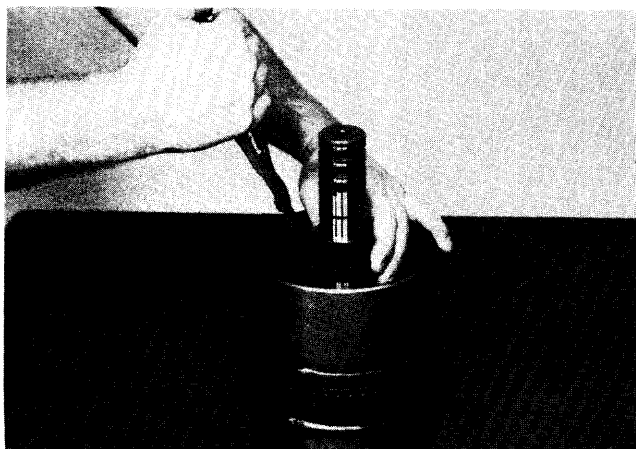


Figure 77

Remove bearing locating ring.



Figure 78

Compress spring retainer washer. Through opening remove spring retainer snap ring. Release tension on spring retainer.



Figure 79

Remove snap ring and snap ring retainer.



Figure 80

Remove disc spring washers. **NOTE:** Non-modulated clutches will have a piston return spring in forward & reverse. See note in Figure 65.

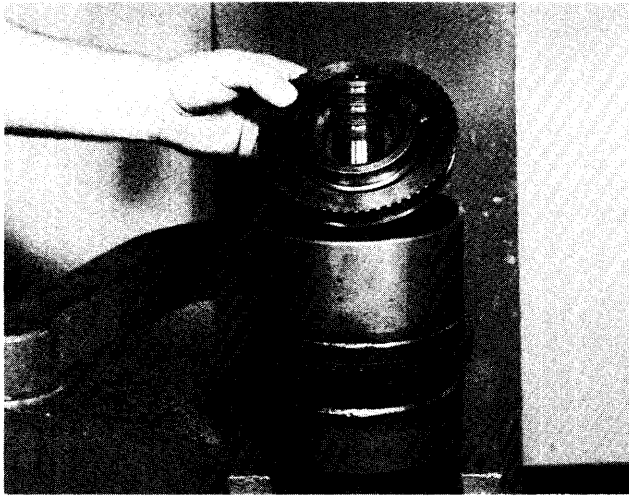


Figure 81

Remove clutch piston.

CLEANING AND INSPECTION

CLEANING

Clean all parts thoroughly using solvent type cleaning fluid. It is recommended that parts be immersed in cleaning fluid and moved up and down slowly until all old lubricant and foreign material is dissolved and parts are thoroughly cleaned.

CAUTION: Care should be exercised to avoid skin rashes, fire hazards and inhalation of vapors when using solvent type cleaners.

Bearings

Remove bearings from cleaning fluid and strike flat against a block of wood to dislodge solidified particles of lubricant. Immerse again in cleaning fluid to flush out particles. Repeat above operation until bearings are thoroughly clean. Dry bearings using moisture-free compressed air. Be careful to direct air stream across bearing to avoid spinning. Do not spin bearings when drying. Bearings may be rotated slowly by hand to facilitate drying process.

Housings

Clean interior and exterior of housings, bearing caps, etc., thoroughly. Cast parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts do not have ground or polished surfaces. Parts should remain in solution long enough to be thoroughly cleaned and heated. This will aid the evaporation of the cleaning solution and rinse water. Parts cleaned in solution tanks must be thoroughly rinsed with clean water to remove all traces of alkali. Cast parts may also be cleaned with steam cleaner.

CAUTION: Care should be exercised to avoid inhalation of vapors and skin rashes when using alkali cleaners.

All parts cleaned must be thoroughly dried immediately by using moisture-free compressed air or soft, lintless absorbent wiping rags free of abrasive materials such as metal filings, contaminated oil or lapping compound.

INSPECTION

The importance of careful and thorough inspection of all parts cannot be overstressed. Replacement of all parts showing indication of wear or stress will eliminate costly and avoidable failures at a later date.

Bearings

Carefully inspect all rollers; cages and cups for wear, chipping or nicks to determine fitness of bearings for further use. Do not replace a bearing cone or cup individually without replacing the mating cup or cone at the same time. After inspection, dip bearings in Automatic Transmission Fluid and wrap in clean lintless cloth or paper to protect them until installed.

Oil Seals, Gaskets, Etc.

Replacement of spring load oil seals, "O" rings, metal sealing rings, gaskets and snap rings is more economical when unit is disassembled than premature overhaul to replace these parts at a future time. Further loss of lubricant through a worn seal may result in failure of other more expensive parts of the assembly. Sealing members should be handled carefully, particularly when being installed. Cutting, scratching, or curling under of lip of seal seriously impairs its efficiency. Apply a thin coat of Permatex No. 2 on the outer diameter of the oil seal to assure an oil tight fit into the retainer. When assembling new metal type sealing rings, same should be lubricated with coat of chassis grease to stabilize rings in their grooves for ease of assembly of mating members. Lubricate all "O" rings and seals with recommended type Automatic Transmission Fluid before assembly.

Gears and Shafts

If magna-flux process is available, use process to check parts. Examine teeth on all gears carefully for wear, pitting, chipping, nicks, cracks or scores. If gear teeth show spots where case hardening is worn through or cracked, replace with new gear. Small nicks may be removed with suitable hone. Inspect shafts and quills to make certain they are not sprung, bent, or splines twisted, and that shafts are true.

Housing, Covers, etc.

Inspect housings, covers and bearing caps to be certain they are thoroughly clean and that mating surfaces, bearing bores, etc., are free from nicks or burrs. Check all parts carefully for evidence of cracks or condition which would cause subsequent oil leaks or failures.

FORWARD AND 2nd CLUTCH REASSEMBLY

(Forward being assembled)

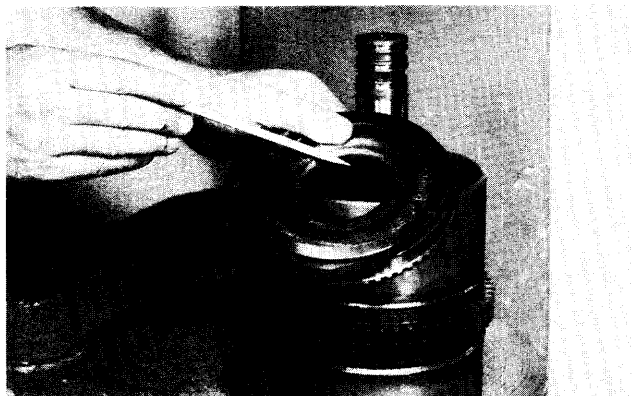


Figure 82

Install new clutch piston inner and outer sealing rings.



Figure 83

Insert clutch piston in clutch drum. **CAUTION:** Do not damage sealing rings. See note in Figure 80.

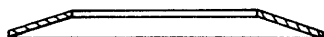
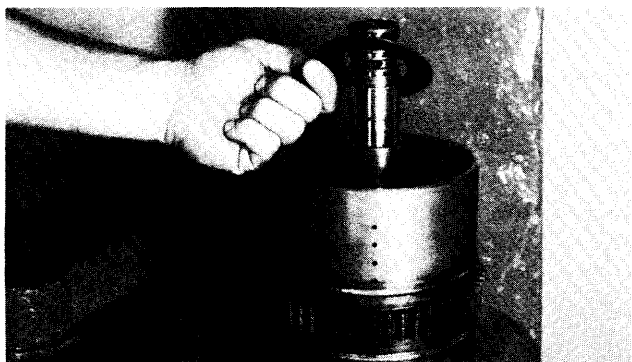


Figure 84

Install 1st disc spring washer, large diameter of bevel down as shown. **NOTE:** Do not mix forward clutch disc spring washers with low clutch washers. See **NOTE** in Figure 65.

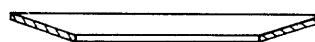
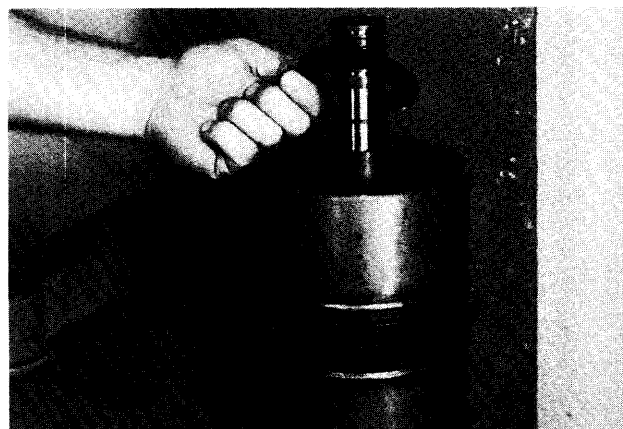


Figure 85

Install 2nd disc spring washer with large diameter of bevel up. Install balance of washers, quantity (7) seven alternating bevel.



Figure 86

Install disc spring snap ring retainer and snap ring. Compress washers and snap ring retainer, install snap ring in lower snap ring groove. Install bearing locating ring. See page 40, Figure A.

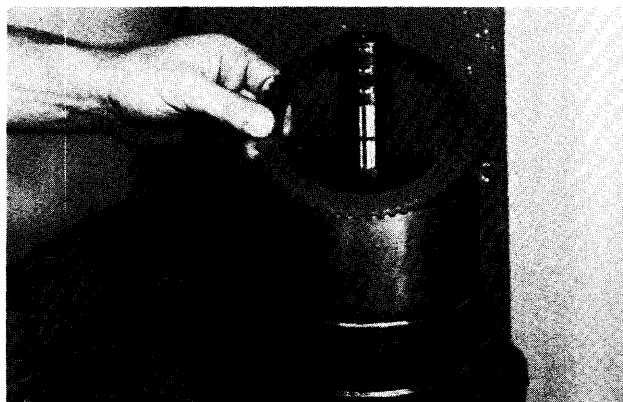


Figure 87

Insert one steel disc.



Figure 88

Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.

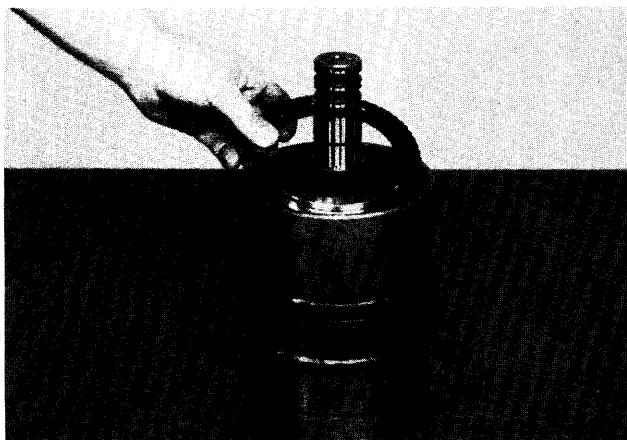


Figure 89

Install end plate.

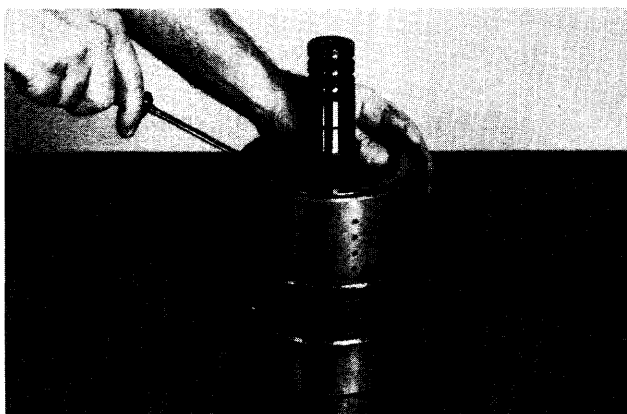


Figure 90

Install end plate retainer ring.

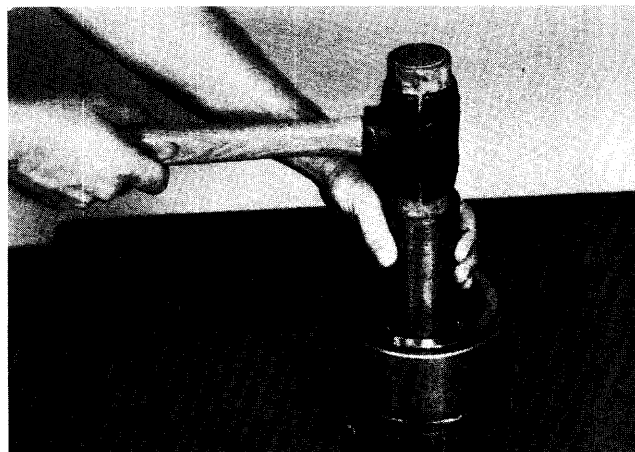


Figure 91

Install clutch driven gear inner bearing. **NOTE: The inner bearing does not have a bearing shield.**

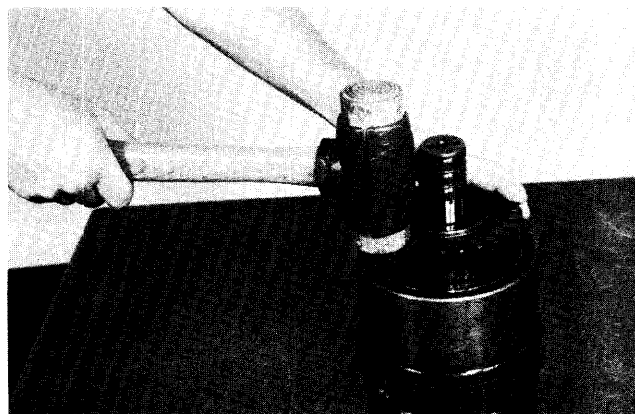


Figure 92

Install clutch driven gear into clutch drum. Align splines on clutch gear with internal teeth of friction discs. Tap gear into position. Do not force this operation. Gear splines must be in full position with internal teeth of all friction discs.

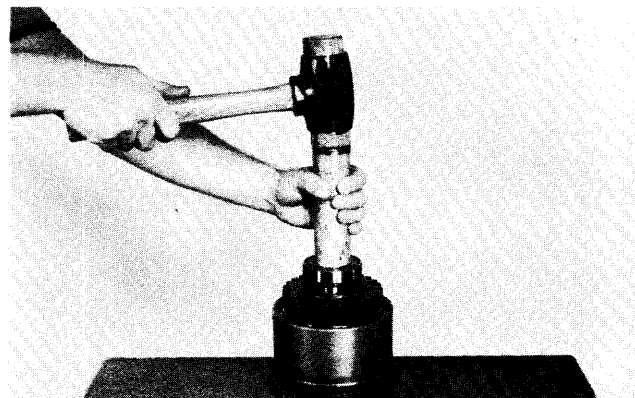


Figure 93

Install driven gear outer bearing. **NOTE: Bearing shield in. See page 43.**

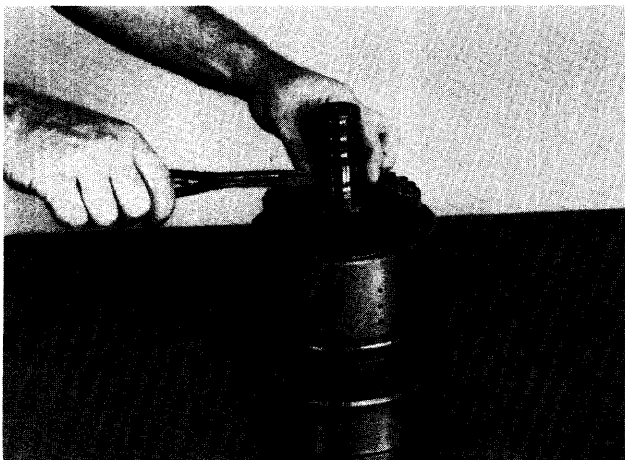


Figure 94
Install front bearing locating ring.

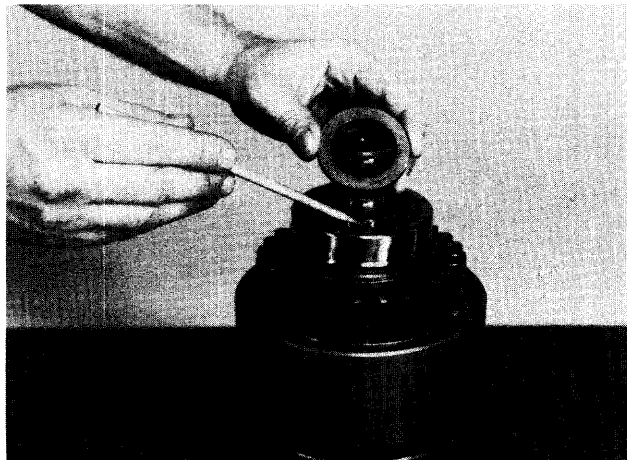


Figure 97
Install lock ball and bearing spacer.

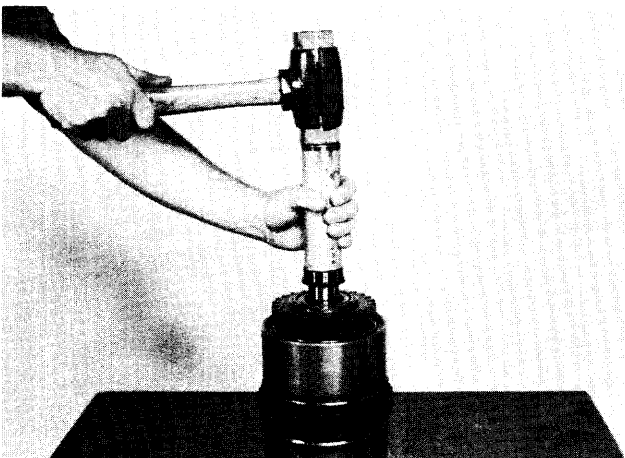


Figure 95
Install front bearing inner race.

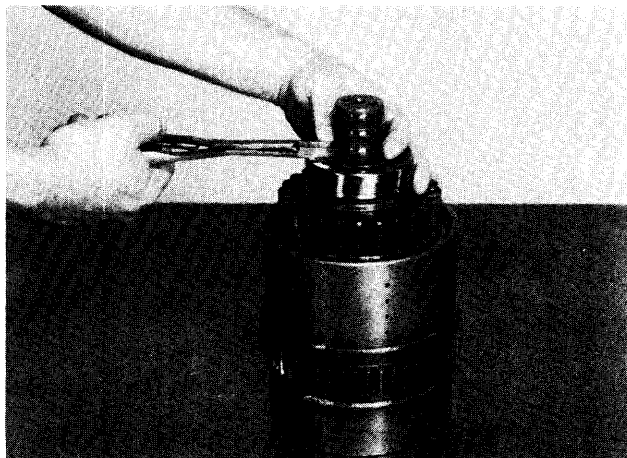


Figure 98
Install bearing retainer ring.

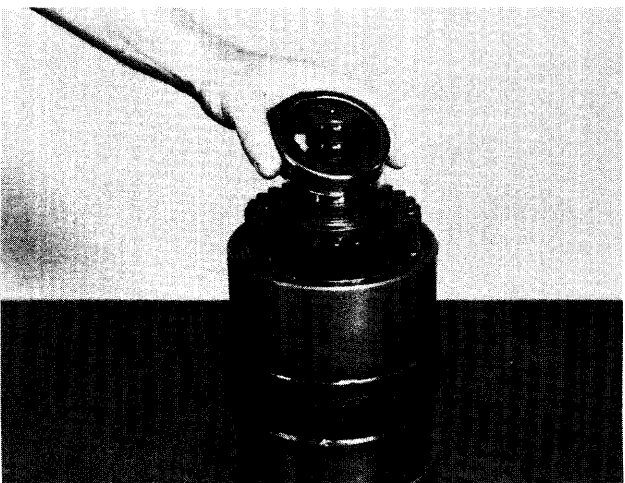


Figure 96
Install front bearing and outer race.



Figure 99
Install piston rings and expander springs as explained on page 67.

FORWARD & REVERSE NON-MODULATED CLUTCHES AND 2nd & 3rd CLUTCH PISTON RETURN SPRING REASSEMBLY

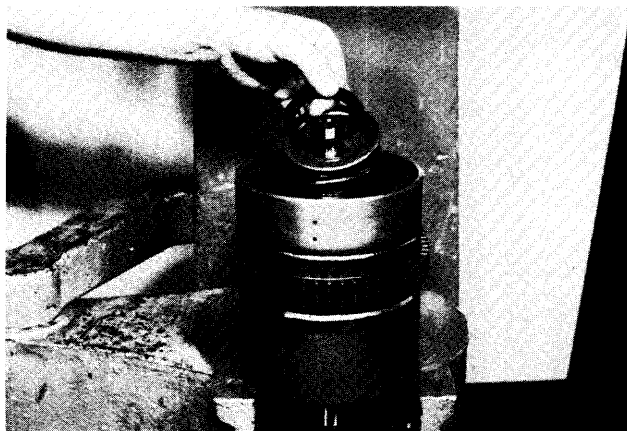


Figure 100

Install new clutch piston inner and outer sealing ring. Insert piston into clutch drum using caution as not to damage seals. Position inner spring retainer, piston return spring, outer spring retainer and retainer snap ring retainer and snap ring. Compress spring and retainer and install snap ring. **See page 40, Figure B.** Assemble clutch discs and end plate as previously explained.

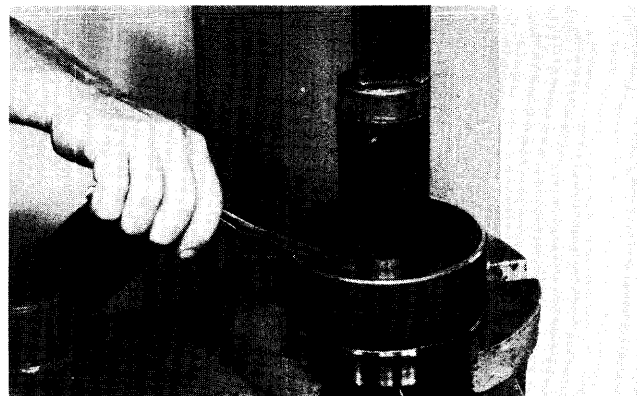


Figure 102

Position piston return disc spring washer snap ring. Compress washers and install snap ring.

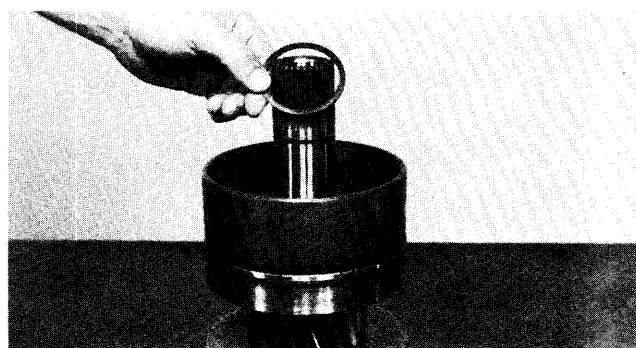


Figure 103

Install snap ring retainer.

LOW CLUTCH REASSEMBLY

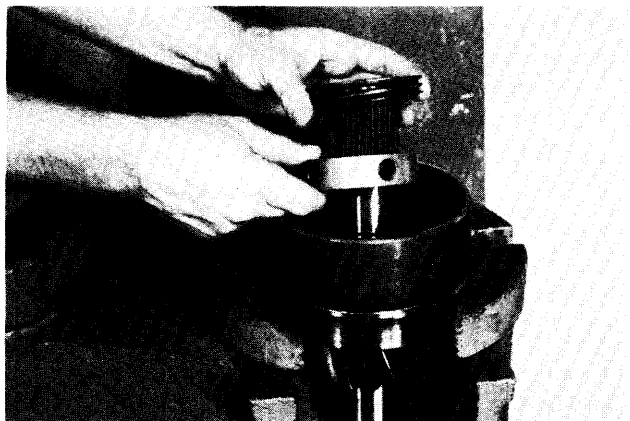


Figure 101

Install new clutch piston inner and outer sealing ring. Insert piston into clutch drum using caution as not to damage seals. Install piston to disc spring washer spacer. **See NOTE in Figure 65.** Install disc spring washers. First washer with large diameter of washer toward spacer. Alternate (5) five washers. **See page 40, Figure C.**

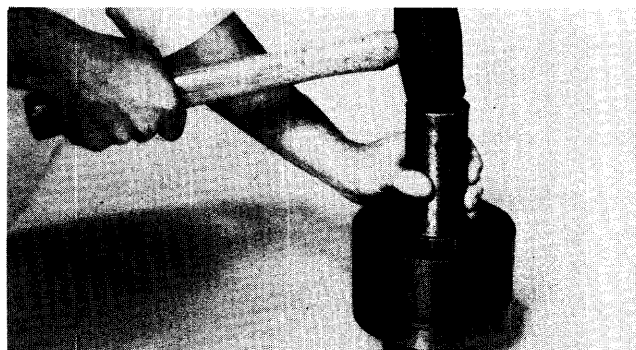


Figure 104

Install low gear inner taper bearing. Install one steel disc. Install one friction disc. **NOTE: The friction discs in the low clutch has a higher co-efficient rating than the friction discs in the other clutches, therefore the discs must not be mixed. The low clutch inner disc can be identified by an "X" stamped on one side of the inner teeth. The low clutch inner disc also has a strip of non-soluble yellow paint sprayed on the outer edge of the disc.** Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.



Figure 105
Install end plate and retainer ring.

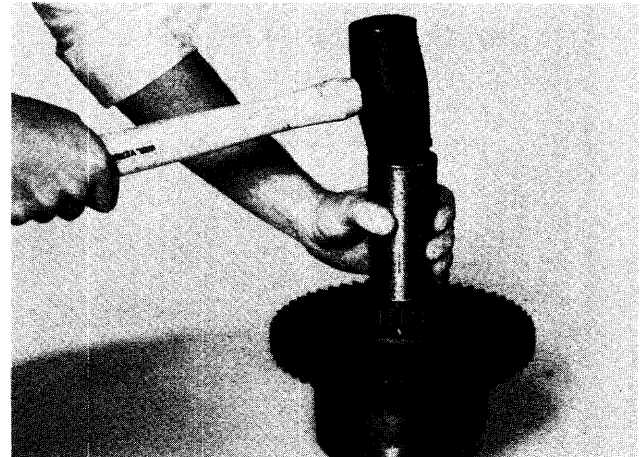


Figure 108
Install low gear outer taper bearing.

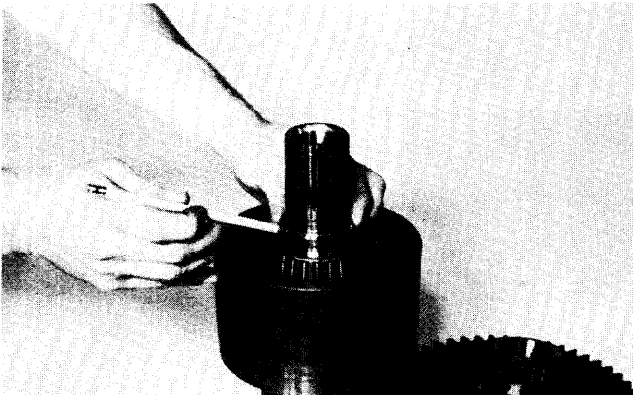


Figure 106
Install low clutch taper bearing spacer. **NOTE:** When installing the 3rd gear in the 3rd speed clutch a bearing spacer is used between the inner and outer 3rd gear bearing also.

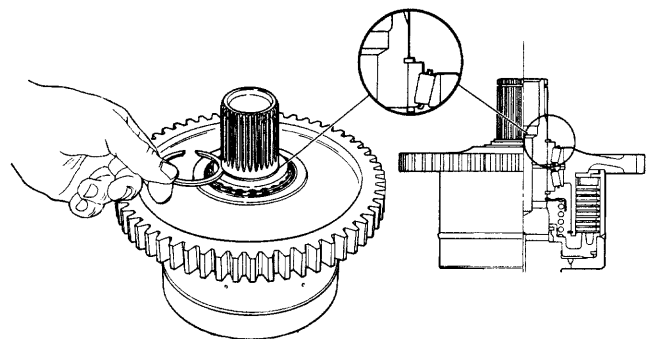


Figure 109

NOTE: Retainer ring is selected at assembly for proper thickness. A snap ring kit is available. Select the thickest of the three rings in the kit that can be fitted into the snap ring groove to assure a proper taper bearing tightness. Check ring as shown for tight ring to bearing fit.



Figure 107
Install low gear into clutch drum. Align splines on low gear with internal teeth of friction discs. Tap gear into position. Do not force this operation. Gear splines must be in full position with internal teeth of all friction discs.

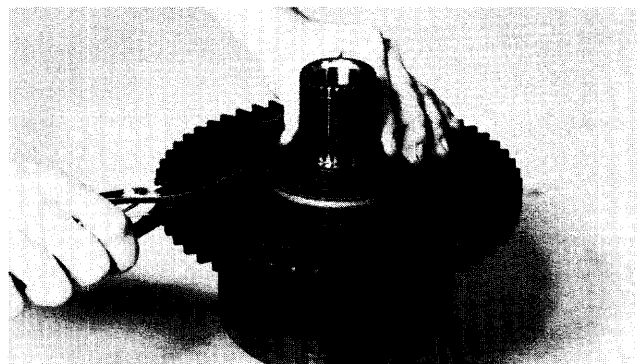


Figure 110
Install low clutch taper bearing retainer ring.

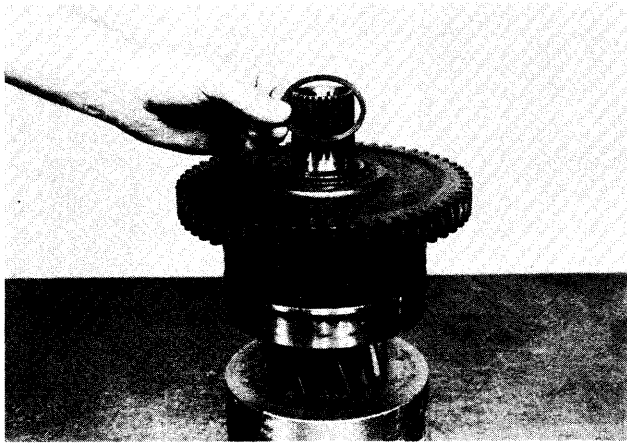


Figure 111

Install low speed gear taper bearing retainer ring retainer.

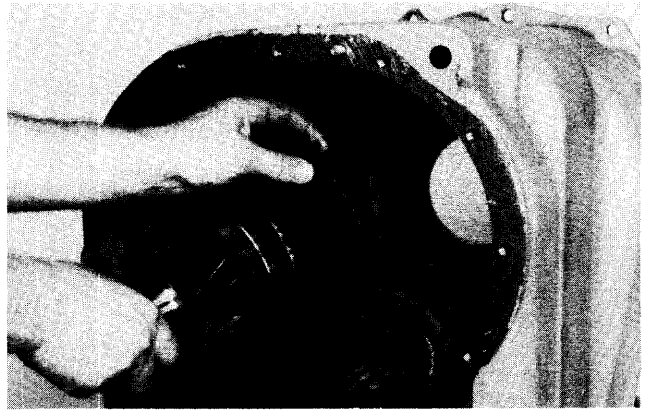


Figure 114

Install low clutch assembly from rear of transmission case.

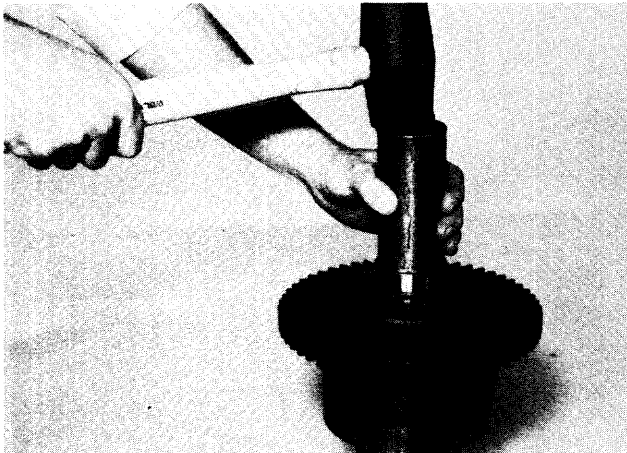


Figure 112

Install low clutch shaft front bearing inner race with large diameter of race down.

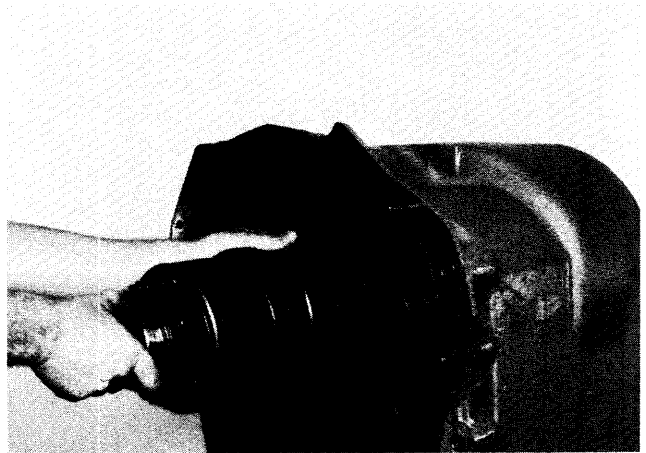


Figure 115

Install reverse and 3rd clutch assembly from the front of the transmission.



Figure 113

Install low clutch front bearing. Roller bearing on 4 speed transmission and a ball bearing on the 3 speed transmission.

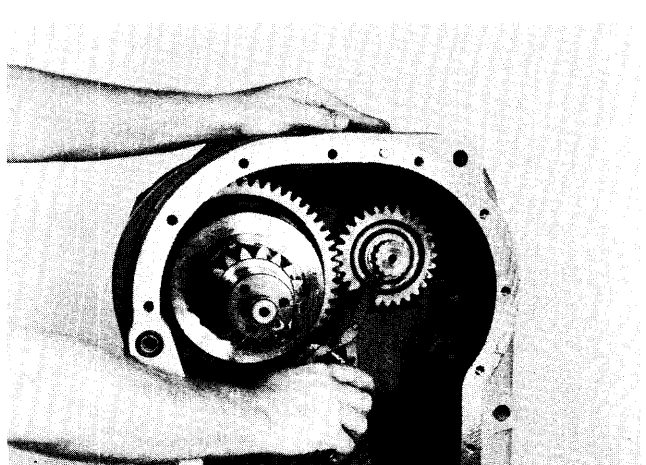


Figure 116

Install low speed drive gear and retainer ring.

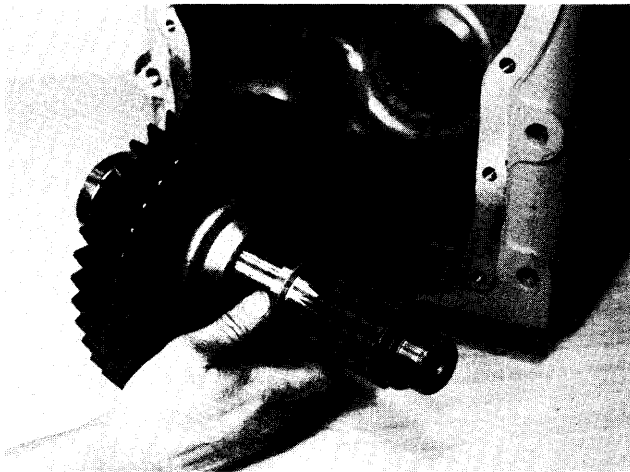


Figure 117

Press output gear on output shaft. Install output gear washer in undercut of gear. (3 speed shown).

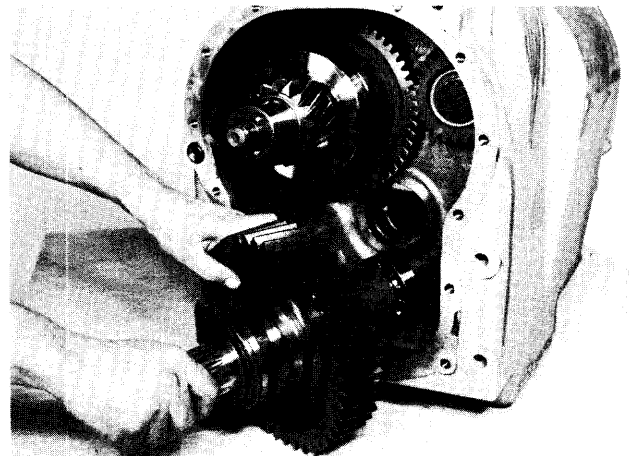


Figure 120

Install output shaft assembly in housing. (3 speed shown).

See caution in Figure 42.

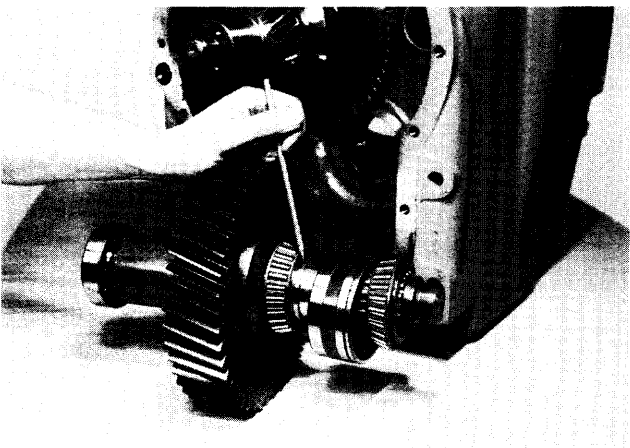


Figure 118

Press inner taper bearing on output shaft. Install double taper bearing spacer, double taper bearing cup and outer taper bearing. (3 speed shown).

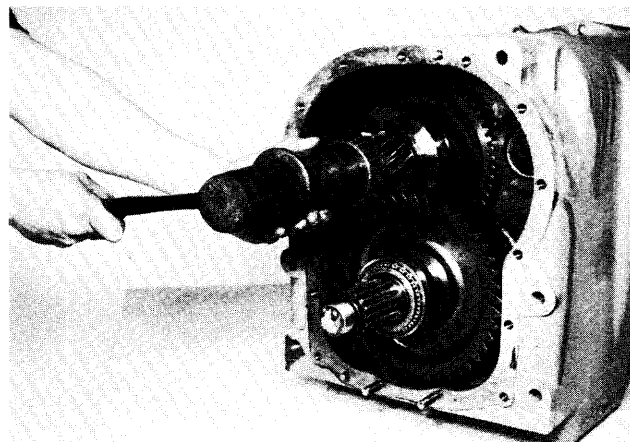


Figure 121

Install low clutch inner taper bearing. **NOTE:** Heat bearing in hot oil prior to installation.

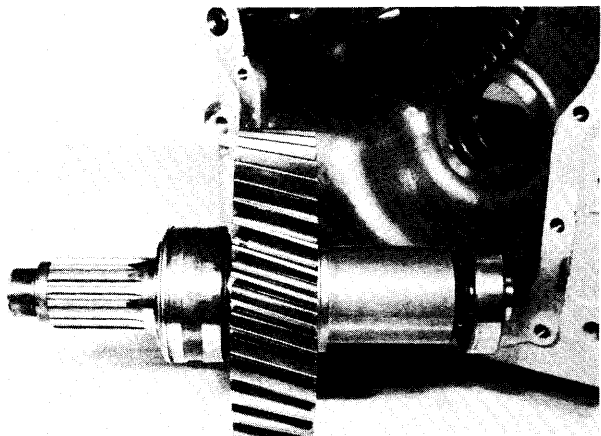


Figure 119

Output shaft assembly. (3 speed shown).

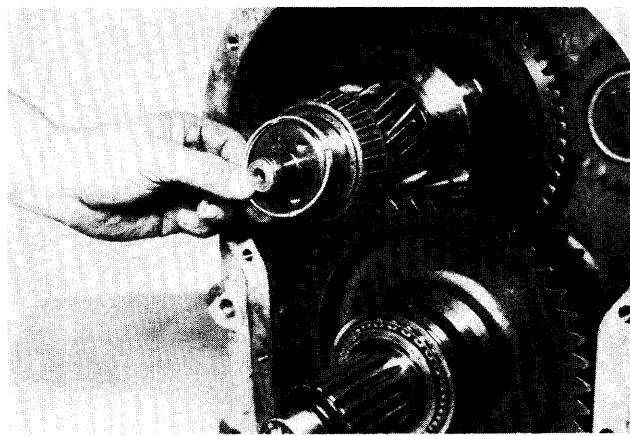


Figure 122

Install bearing spacer and double bearing cup.

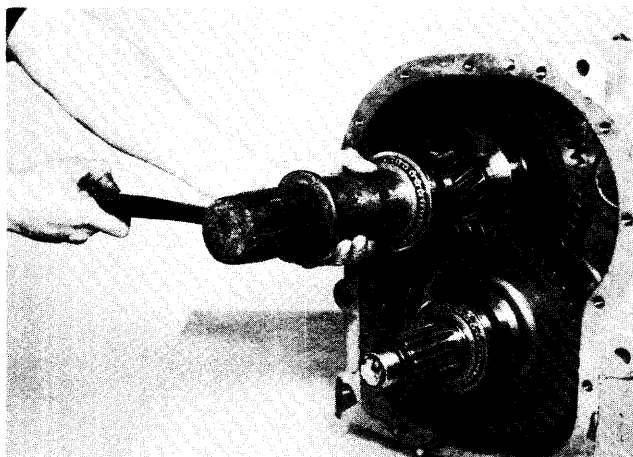


Figure 123

Install outer taper bearing. **NOTE:** Heat bearing in hot oil prior to installation.

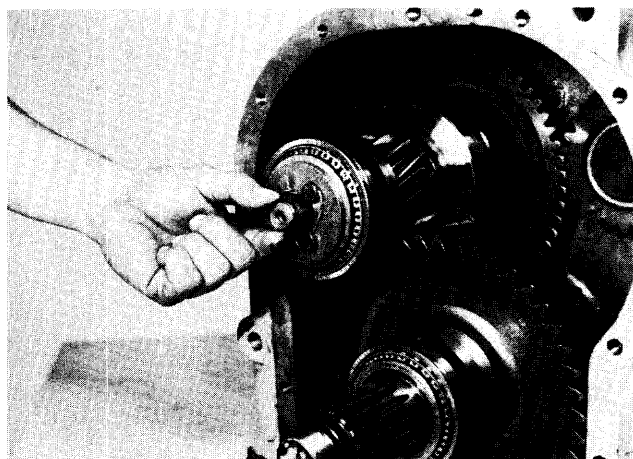


Figure 126

Install low clutch shaft oil sealing ring.

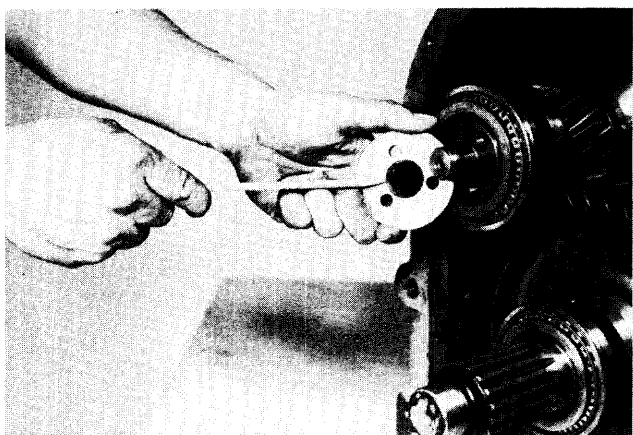


Figure 124

Install bearing retainer plate, inner diameter chamfer toward bearing.

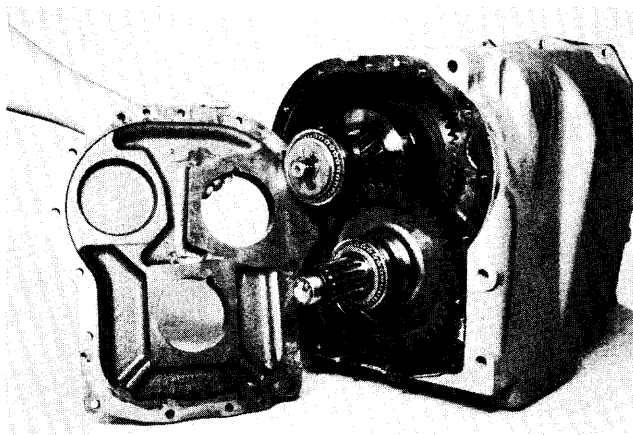


Figure 127

Install alignment studs and new gasket. Place lock balls in low shaft and idler shaft. A light coat of grease will hold lock balls in place. Position shafts so lock balls align with notches in rear cover.

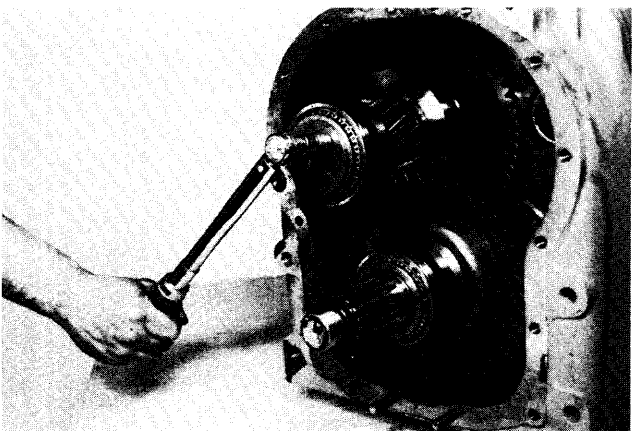


Figure 125

Install bolts, block gears to prevent turning. Tighten bolts to specified torque. Lockwire bolts to prevent loosening.

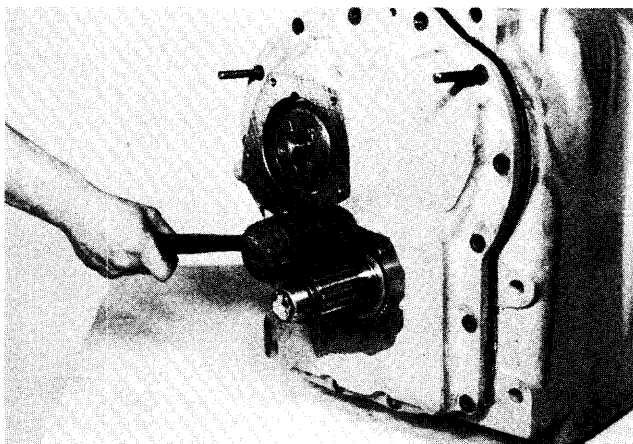


Figure 128

Tap cover in place and secure with bolts and lockwashers.

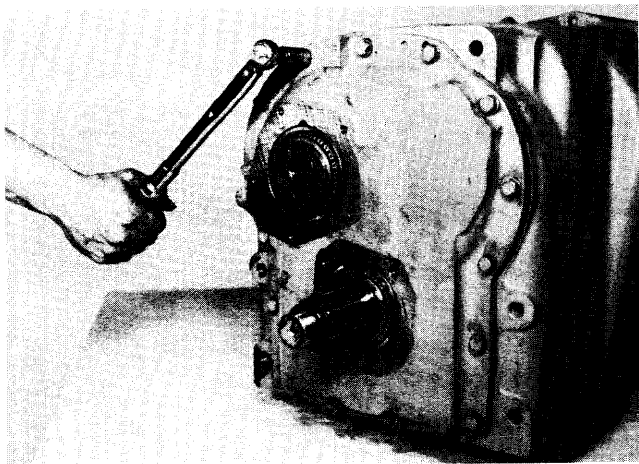


Figure 129

Tighten cover bolts to specified torque.

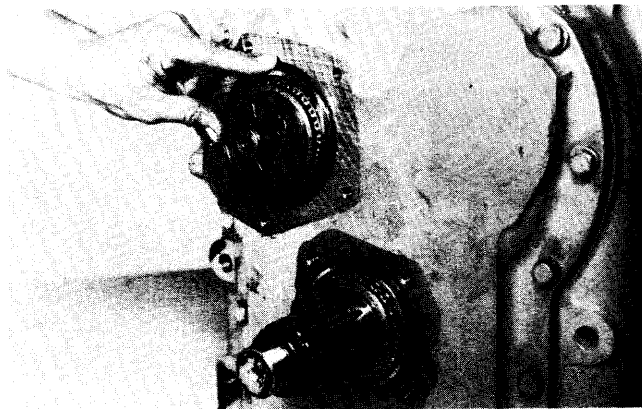


Figure 130

Install the output shaft and low clutch shaft rear bearing locating ring. Be certain ring is in full position in ring groove.

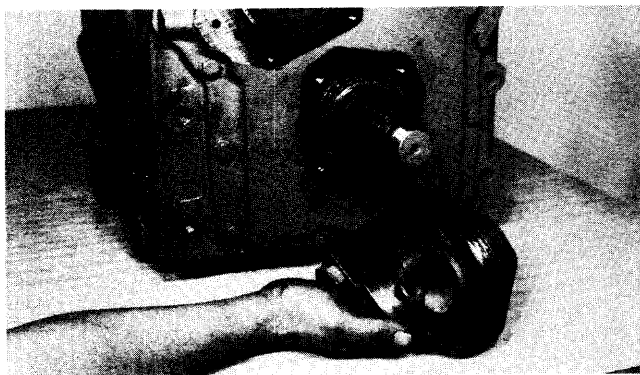


Figure 131

Coat outer diameter of oil seal with Permatex No. 2 and press seal in the output shaft bearing cap with lip of seal in. Position new gasket on bearing cap. Install bearing cap on transmission housing. Install bolts and lockwashers, tighten to specified torque.

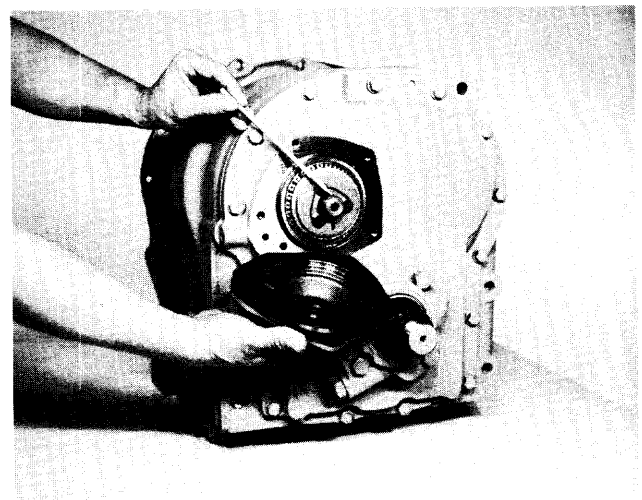


Figure 132

Install new "O" ring and gasket on low clutch bearing cap. Position cap over clutch shaft, use caution as not to damage oil sealing ring.

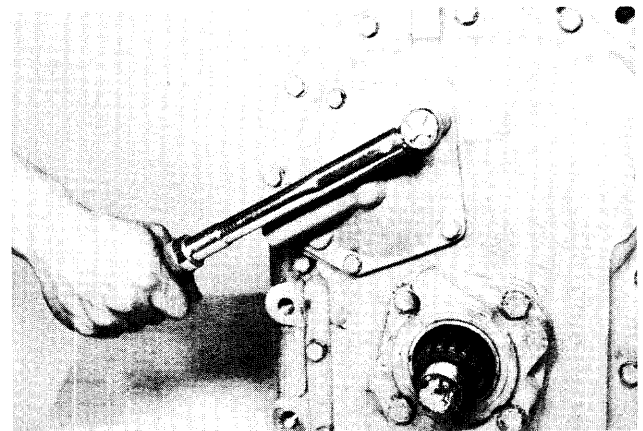


Figure 133

Install bolts and washers, tighten to specified torque.

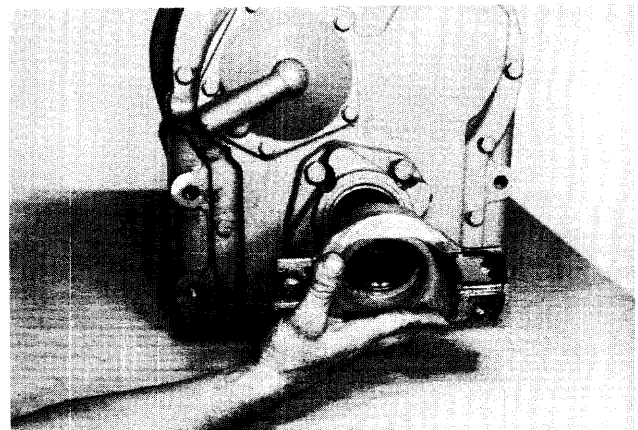


Figure 134

Install output flange on output shaft.

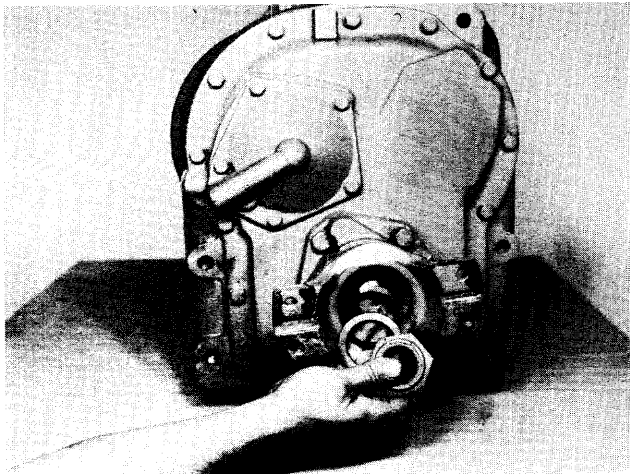


Figure 135

Install the output flange "O" ring, washer and flange nut. Block output flange to prevent from turning. See elastic stop nut torque chart, Figure H.

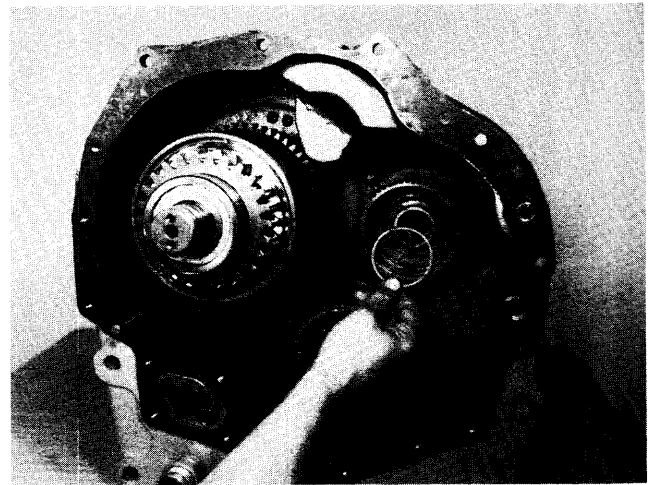


Figure 138

Install 2nd speed gear retaining ring retainer.

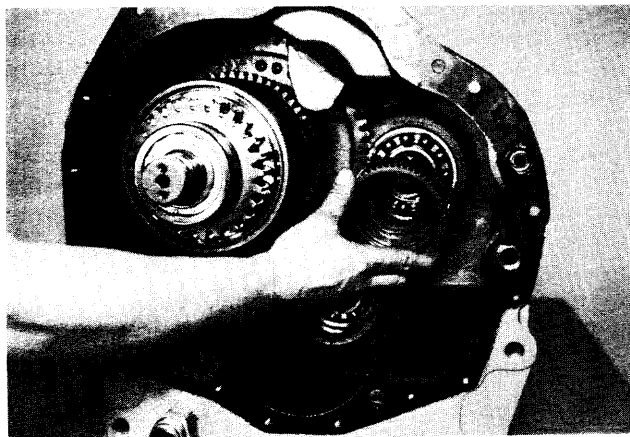


Figure 136

Install 2nd speed gear on low clutch shaft. **NOTE:** The 4 speed transmission has a bearing end plate between the 2nd gear and bearing.

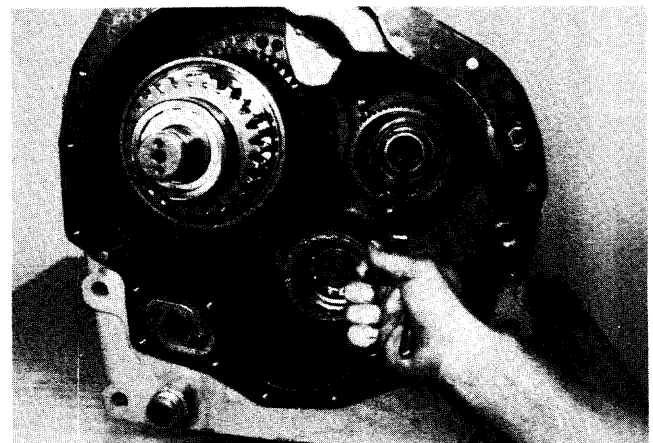


Figure 139

Install 2nd gear ring retainer snap ring.

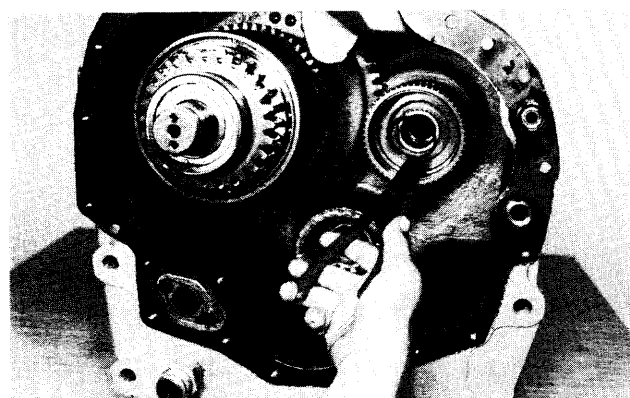


Figure 137

Install 2nd speed gear retainer ring.

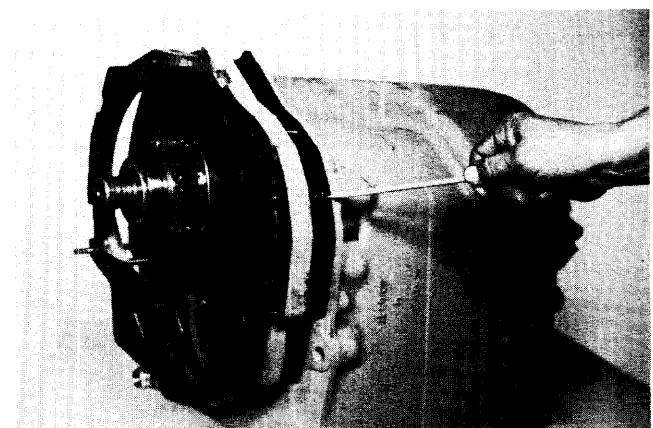


Figure 140

Install transmission case gasket and "O" rings. Install housing spacer. **NOTE:** Housing spacer is used with 12 plate clutch modulation only.

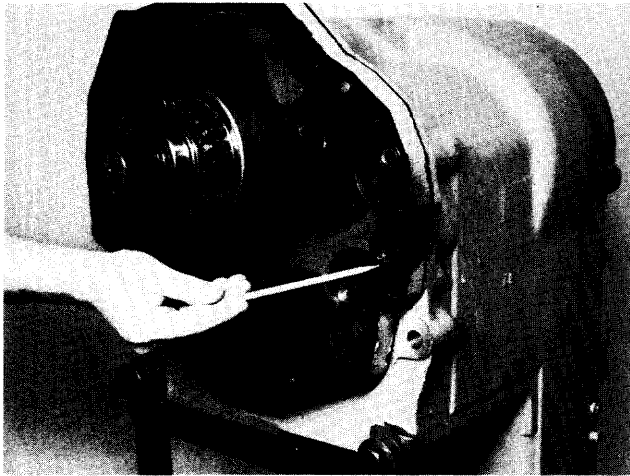


Figure 141

Install housing spacer gasket and "O" rings. See R-Model section for front cover installation.

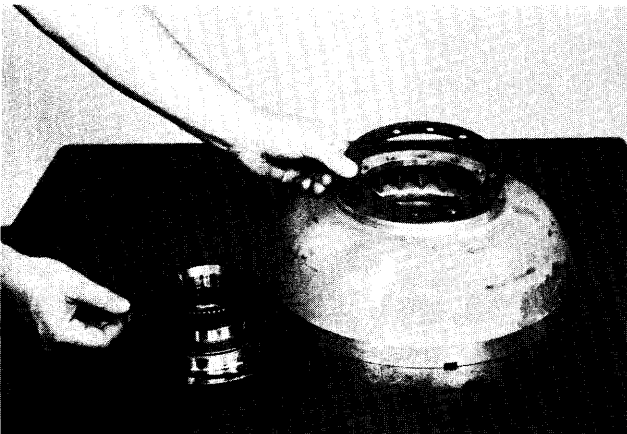


Figure 142

Clean impeller hub mounting surface and tapped holes with solvent. Dry thoroughly being certain tapped holes are dry and clean. Install new "O" ring on impeller hub. Position impeller hub screw backing ring.

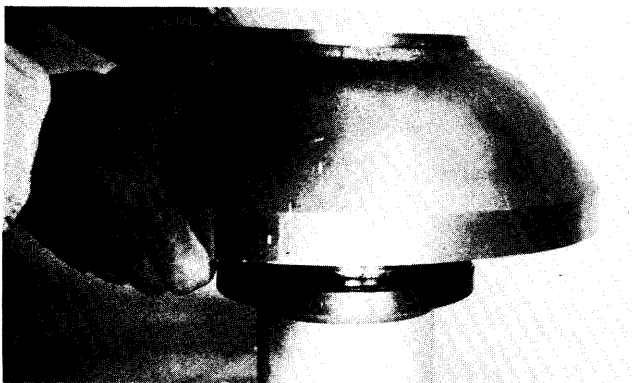


Figure 143

Align holes in impeller hub with holes in impeller and backing ring.

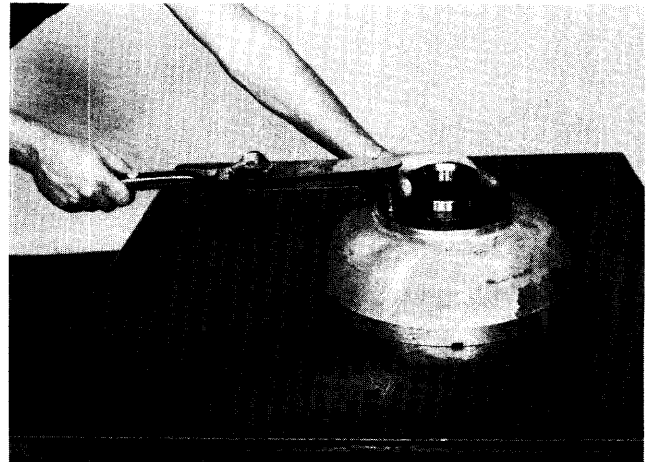


Figure 144

Install (12) impeller hub special screws to approximately .06 inch [1,5] of seated position. With a calibrated torque wrench, tighten screws to 40-45 lbs. ft. [54,3-61,0 N.m] torque. **NOTE:** Assembly of impeller to impeller hub must be completed within a fifteen minute period from start of screw installation. The screws are prepared with coating which begins to harden after installation in the impeller hub holes. If not tightened to proper torque within the fifteen minute period, insufficient screw clamping tension will result. The special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced.

The compound left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.

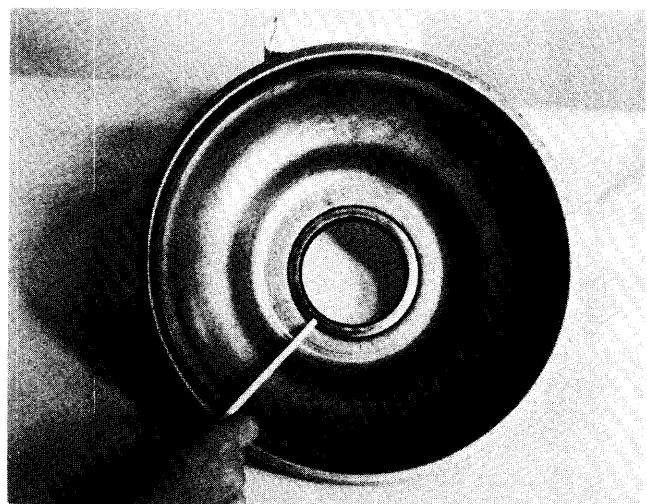


Figure 145

Apply a light coat of Permatex No. 2 on the outer diameter of the oil baffle seal. Press seal in oil baffle with lip of seal down. (**NOTE: When baffle is positioned on impeller, lip of oil seal will be up.**)

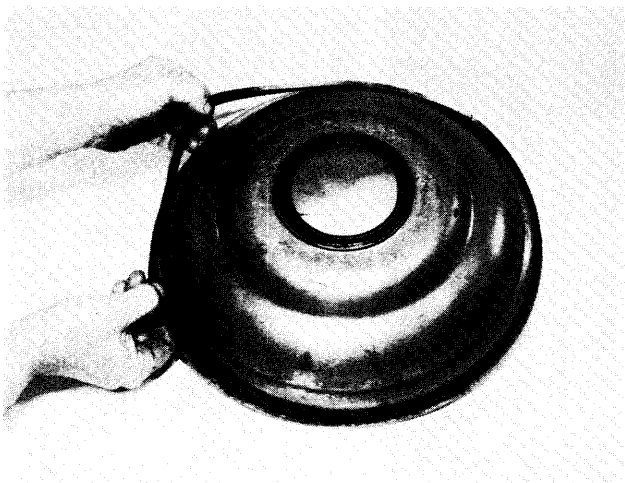


Figure 146
Install a new oil baffle seal ring.



Figure 149
Secure impeller hub gear with retainer ring.



Figure 147
Install oil baffle on impeller assembly. See Note in Figure 145.

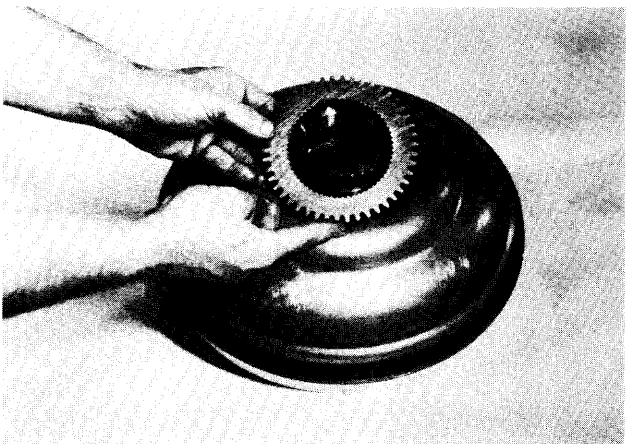


Figure 148
Install impeller hub gear.

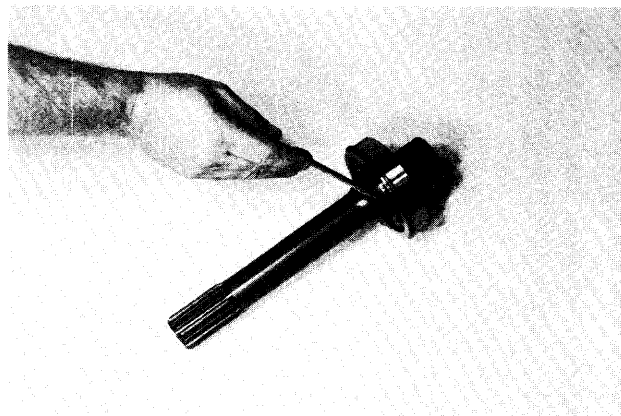


Figure 150
Install new turbine shaft piston ring.

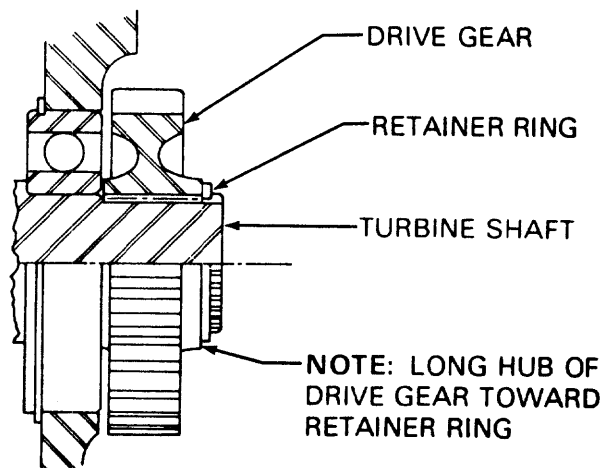


Figure 151
Tap turbine shaft and bearing assembly into converter housing from front. At the rear of the converter housing install turbine shaft gear and retainer ring as shown.

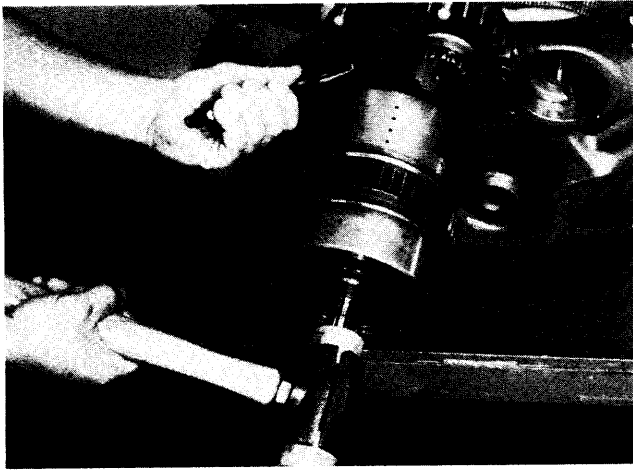


Figure 152

Support converter housing with chain fall. Spread forward clutch front bearing retainer ring and tap forward and 2nd clutch assembly into transmission case assembly. Be certain snap ring is in full position in ring groove.

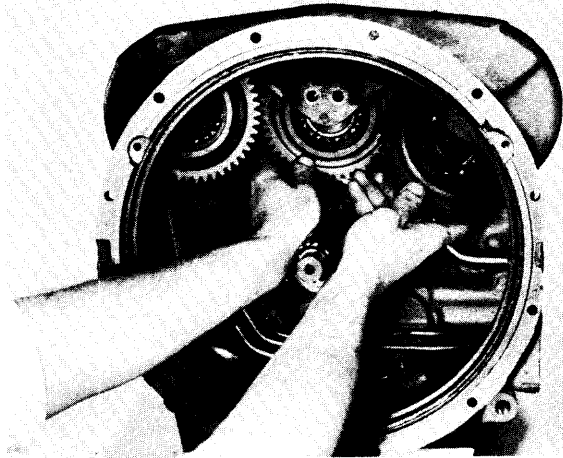


Figure 155

Install right pump drive gear.

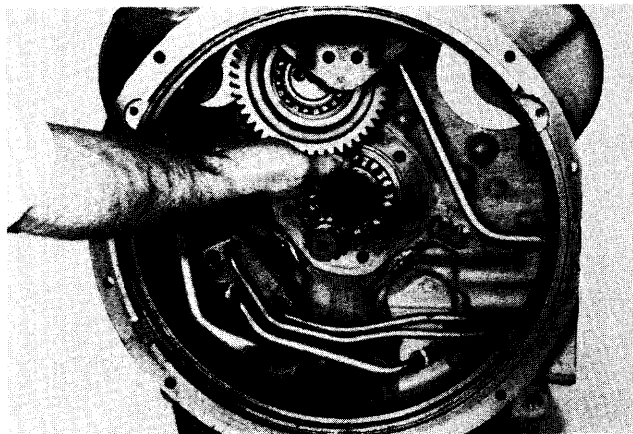


Figure 153

Position center pump drive gear.

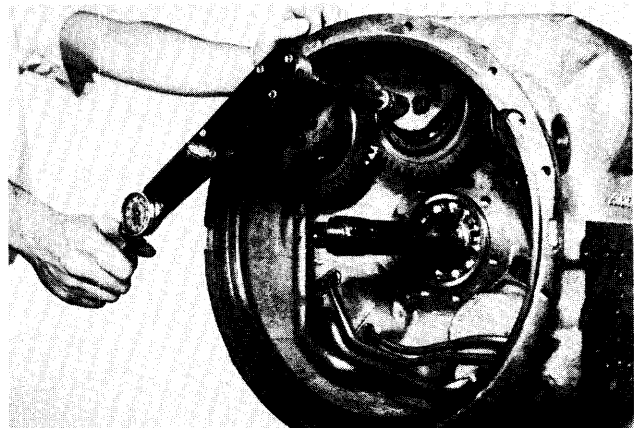


Figure 156

Align holes in pump drive gear bearing supports with holes in converter housing. Install bolts and washers and tighten to specified torque.

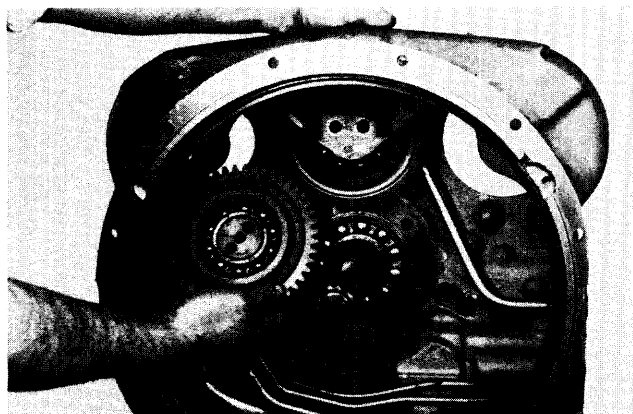


Figure 154

Install left pump drive gear.

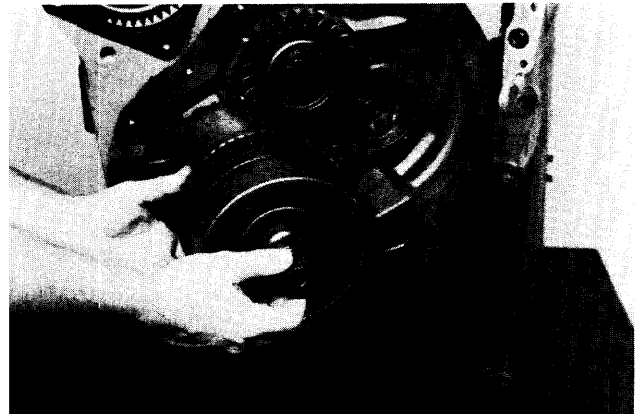


Figure 157

Install 2nd speed clutch pilot bearing.

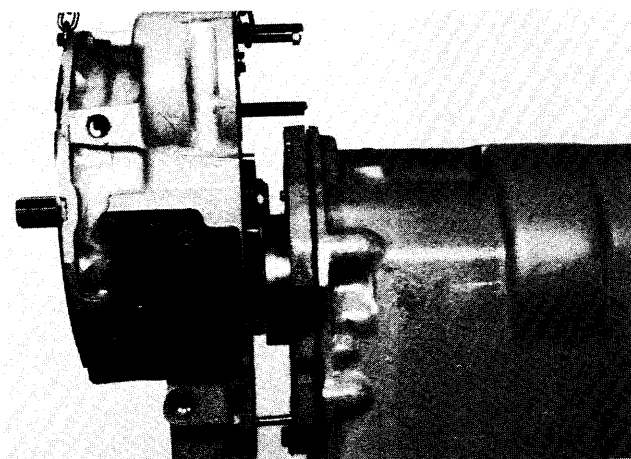


Figure 158

Install alignment studs and position converter housing on studs. **NOTE:** Turn output shaft to align clutch disc hub in clutch. **Do not force this operation.**

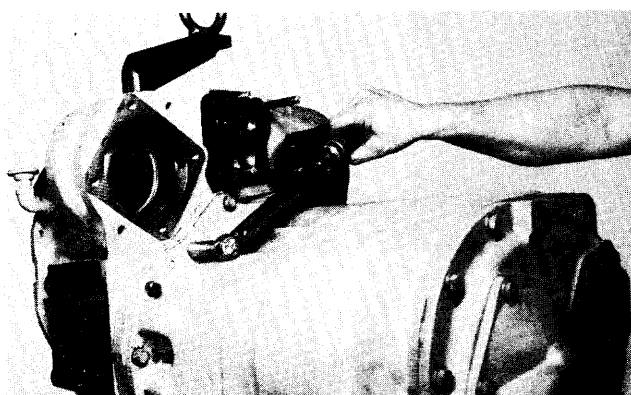


Figure 159

Install converter housing to transmission housing bolts and tighten to specified torque. **NOTE:** Bolts are not to be used to pull converter housing to transmission housing.



Figure 160

Install new sealing ring expander spring and oil sealing ring on support. **NOTE:** Expander spring gap to be 180° from sealing ring hook joint. Position support on turbine shaft, turn support to clear pump drive gear. Align support holes with converter housing.

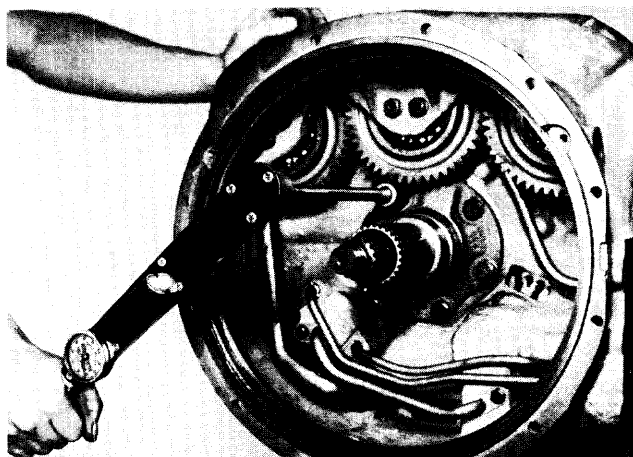


Figure 161

Install stator support bolts and tighten to specified torque.

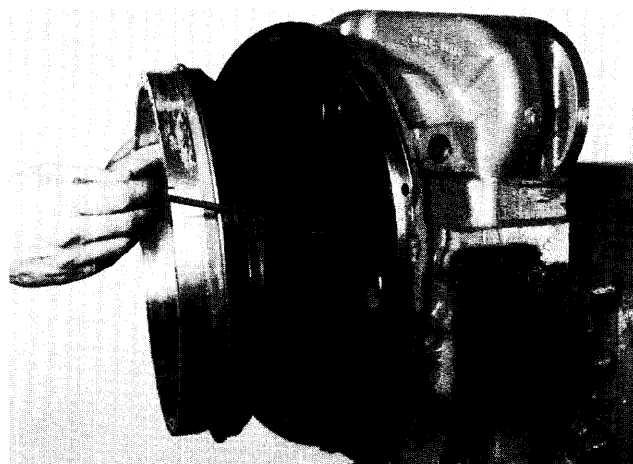


Figure 162

Grease stator support piston ring, oil baffle oil seal and seal ring to facilitate reassembly. Install impeller and oil baffle assembly in converter housing.



Figure 163

Position oil baffle in housing. Secure with oil baffle retainer ring, being sure ring is in full position in ring groove.

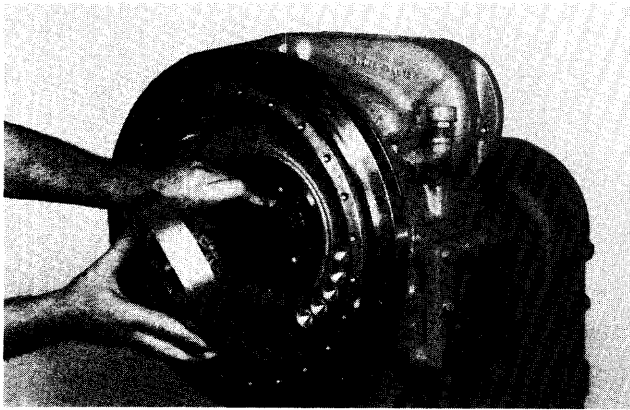


Figure 164

Install reaction member spacer with tang facing out. Install reaction member.

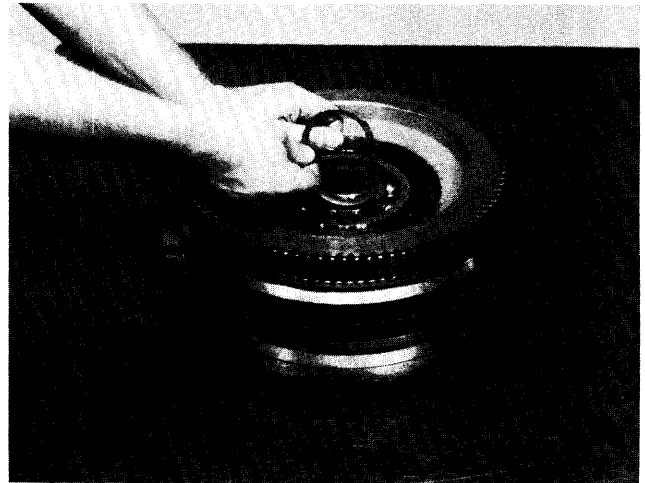


Figure 167

Install spacer and turbine to impeller cover bearing snap ring.

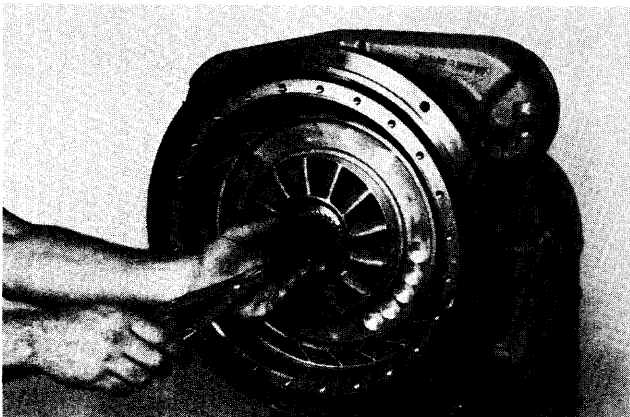


Figure 165

Install reaction member retainer ring.

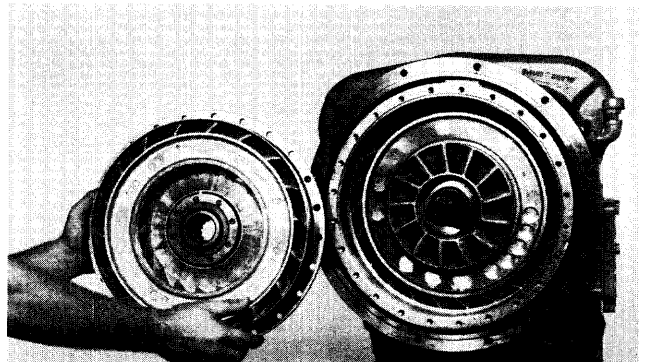


Figure 168

Position new impeller to impeller cover "O" ring on impeller. Install turbine and impeller cover.

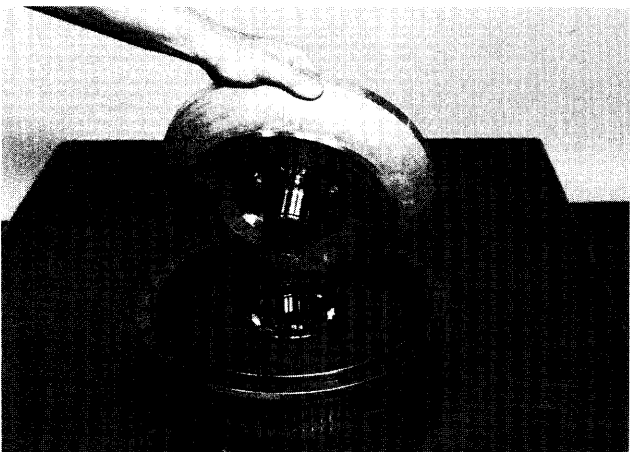


Figure 166

Position turbine in impeller cover.

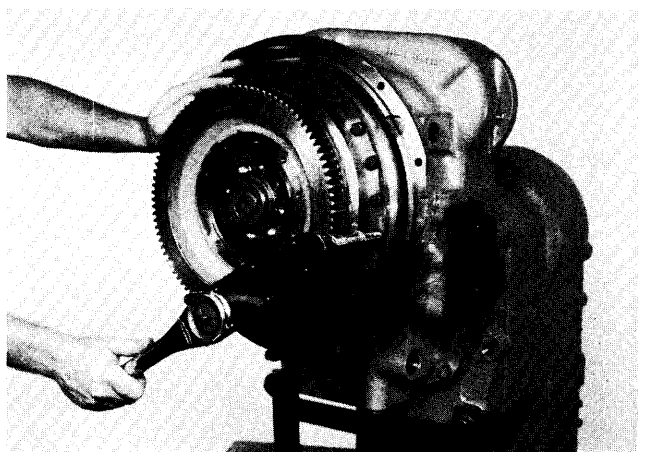


Figure 169

Install impeller cover bolts and torque to specifications.

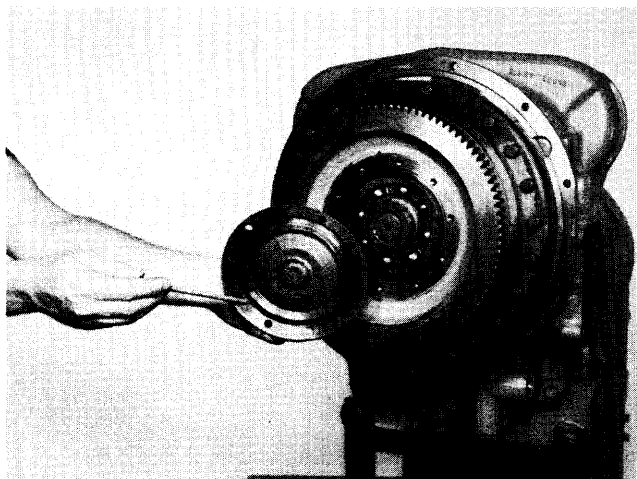


Figure 170

Install new "O" ring seal in impeller cover bearing cap.

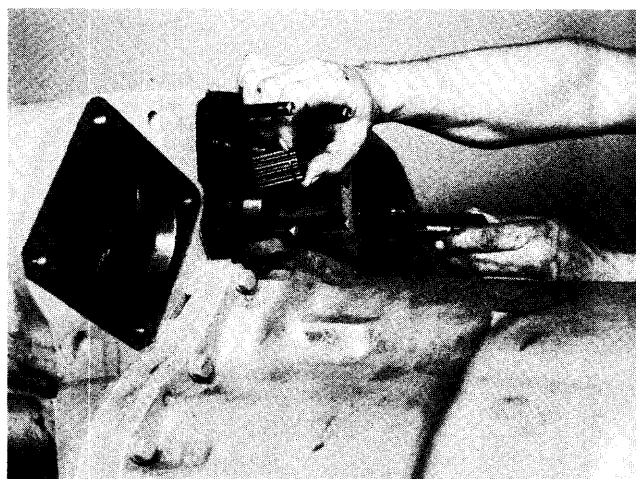


Figure 173

Install pump drive sleeves.

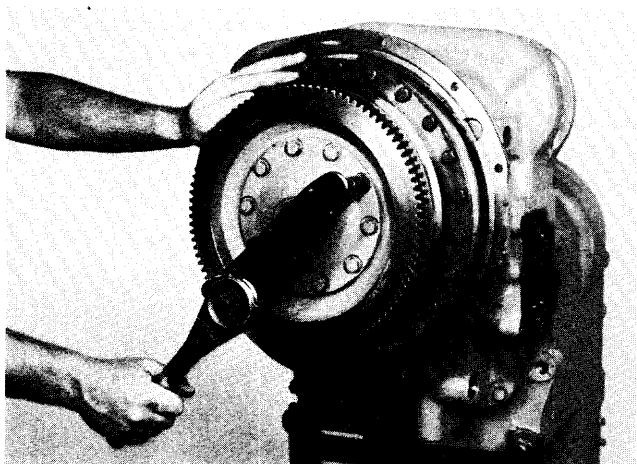


Figure 171

Install bearing cap and bolts, torque to specifications.

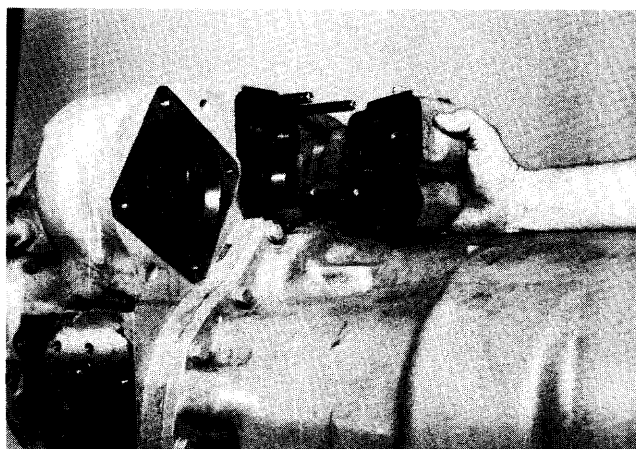


Figure 174

Position a new gasket and "O" rings on the pressure regulating valve. Install valve assembly on studs.

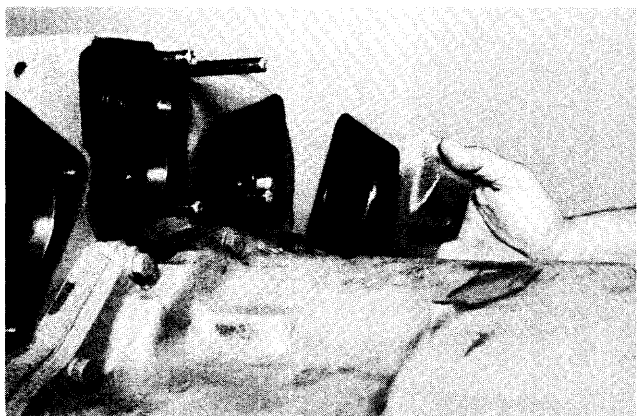


Figure 172

Position auxiliary pump adaptor on housing. Install adaptor bolts and washers, tighten to specified torque. (Adaptors may vary.)

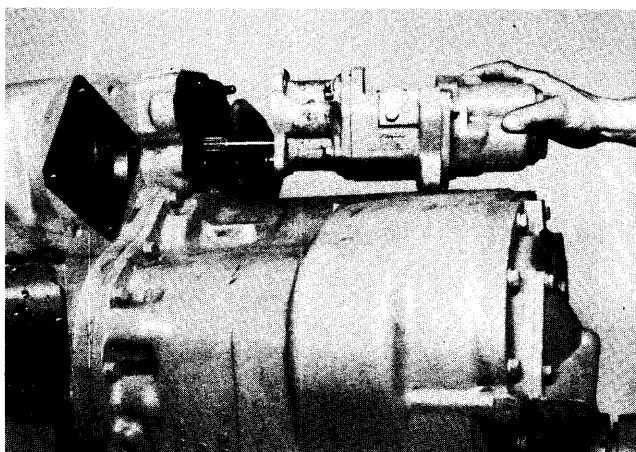


Figure 175

Install pump assembly on studs. **NOTE:** Pump assemblies may vary.

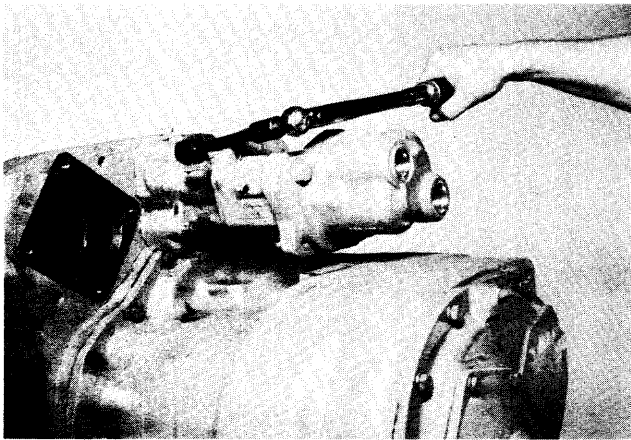


Figure 176

Tighten pump stud nuts to specified torque.

Control valve assemblies may vary. The one shown being assembled on converter housing is an electric valve with modulated shift.

The use of aligning studs will facilitate valve to housing assembly.

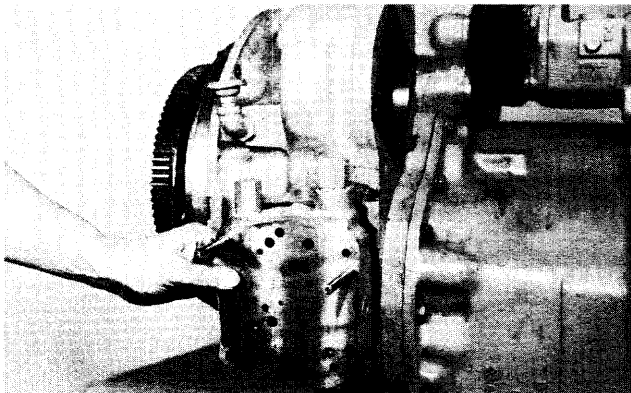


Figure 177

Position a new modulator to housing gasket and modulator valve assembly on aligning studs.

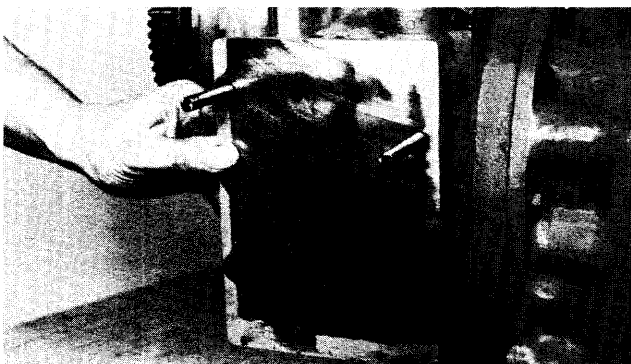


Figure 178

Position modulator valve opening plate gasket and plate on studs.

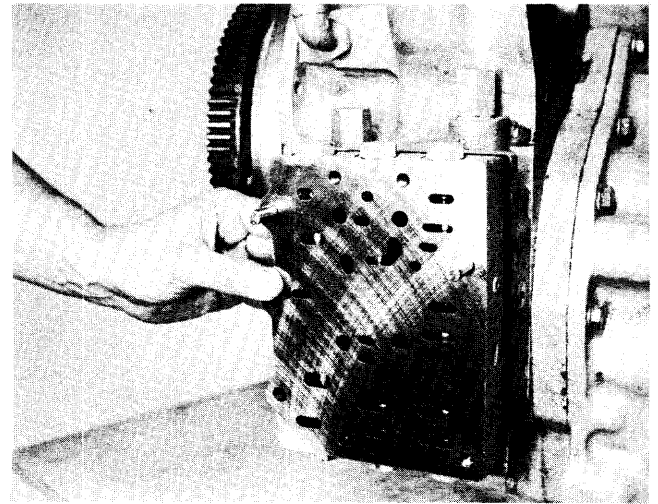


Figure 179

Position valve plate to control valve gasket and control valve on studs.

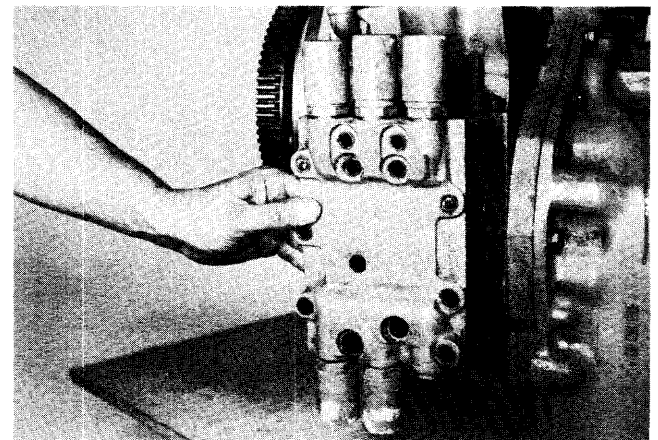


Figure 180

Position new control valve to solenoid valve housing gasket and solenoid housing on studs.

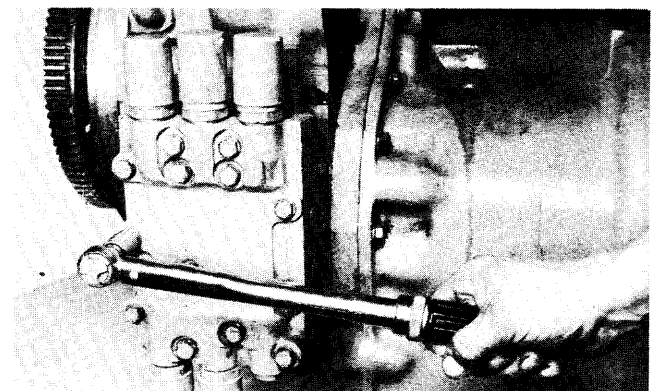


Figure 181

Install control valve assembly to converter housing bolts and washers. Tighten to specified torque.

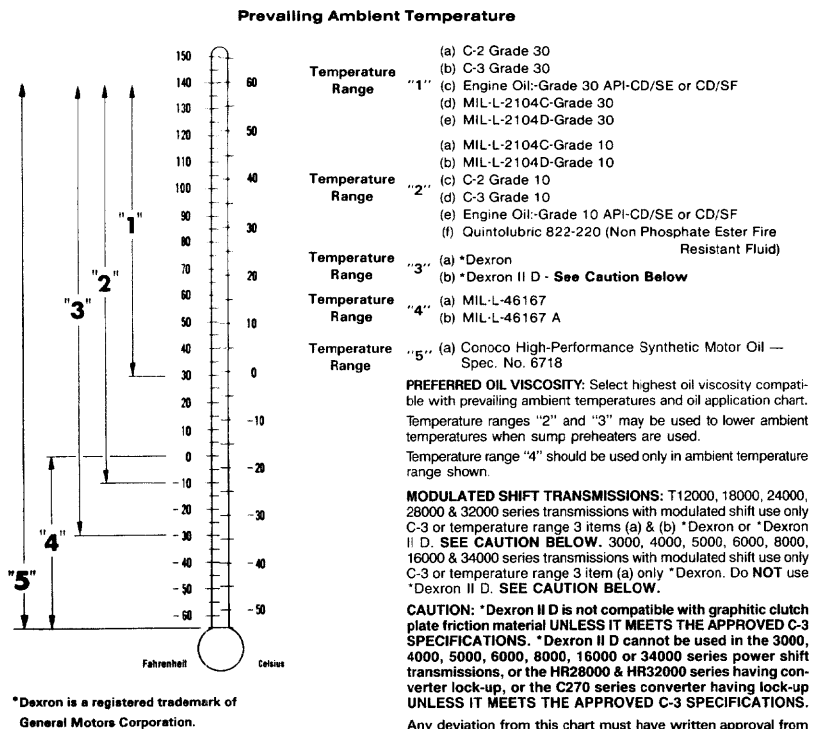
SPECIFICATIONS AND SERVICE DATA—POWER SHIFT TRANSMISSION AND TORQUE CONVERTER

CONVERTER OUT PRESSURE	Converter outlet oil temp. 180° - 200° F. [82,3° - 93,3° C]. Transmission in NEUTRAL . Operating specifications: 25 P.S.I. [172,4 kPa] minimum pressure at 2000 R.P.M. engine speed AND a maximum of 70 P.S.I. [482,6 kPa] outlet pressure with engine operating at no-load governed speed.	OIL FILTRATION	Full flow oil filter safety by-pass, also strainer screen in sump at bottom of transmission case.
CONTROLS	Forward and Reverse — Manual Speed Selection — Manual	CLUTCH PRESSURE	240 - 300 psi [1654,8 - 2068,4 kPa] — With parking brake set (see note), oil temperature 180° - 200°F. [82,2° - 93,3°C], engine at idle (400 to 600 RPM), shift thru direction and speed clutches. All clutch pressure must be equal within 5 psi. [34,5 kPa]. If clutch pressure varies in any one clutch more than 5 psi [34,5 kPa] repair clutch.
CLUTCH TYPE	Multiple discs, hydraulically actuated, spring released, automatic wear compensation and no adjustment. All clutches oil cooled and lubricated.		NOTE: Never use service brakes while making clutch pressure checks. Units having brake actuated declutching in forward and/or reverse will not give a true reading.
CLUTCH INNER DISC	Friction.		ALWAYS USE PARKING BRAKE WHEN MAKING CLUTCH PRESSURE CHECKS.
CLUTCH OUTER DISC	Steel.		

LUBRICATION

RECOMMENDED LUBRICANTS FOR CLARK-HURTH COMPONENTS POWER SHIFTED TRANSMISSION AND TORQUE CONVERTERS

TYPE OF OIL	See Lube Chart.
CAPACITY	Consult Operator's Manual on applicable machine model for system capacity. Torque Converter, Transmission and allied hydraulic system must be considered as a whole to determine capacity.
CHECK PERIOD	Check oil level DAILY with engine running at 500-600 RPM and oil at 180° to 200° F. [82,2 - 93,3° C]. Maintain oil level to FULL mark.
NORMAL * DRAIN PERIOD	Every 500 hours, change oil filter element. Every 1000 hours, drain and refill system as follows: Drain with oil at 150° to 200° F. [65,6 - 93,3° C]. NOTE: It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units. (a) Drain transmission and remove sump screen. Clean screen thoroughly and replace, using new gaskets. (b) Drain oil filters, remove and discard filter elements. Clean filter shells and install new elements. (c) Refill transmission to LOW mark. (d) Run engine at 500-600 RPM to prime converter and lines. (e) Recheck level with engine running at 500 - 600 RPM and add oil to bring level to LOW mark. When oil temperature is hot (180-200° F.) [82,2-93,3° C] make final oil level check. BRING OIL LEVEL TO FULL MARK.



*** Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions judgment must be used to determine the required change intervals.**

TROUBLE SHOOTING GUIDE

For The R and HR Model, 32000 Transmission

The following data is presented as an aid to locating the source of difficulty in a malfunctioning unit. It is necessary to consider the torque converter charging pump, transmission, oil cooler, and connecting lines as a complete system when running down the source of trouble since the proper operation of any unit there-in depends greatly on the condition and operations of

the others. By studying the principles of operation together with data in this section, it may be possible to correct any malfunction which may occur in the system.

TROUBLE SHOOTING PROCEDURE BASICALLY CONSISTS OF TWO CLASSIFICATIONS: MECHANICAL AND HYDRAULIC.

MECHANICAL CHECKS

Prior to checking any part of the system from a hydraulic standpoint, the following mechanical checks should be made:

1. A check should be made to be sure all control lever linkage is properly connected and adjusted at all connecting points.

2. Check shift levers and rods for binding or restrictions in travel that would prevent full engagement. Shift levers by hand at control valve, if full engagement cannot be obtained, difficulty may be in control cover and valve assembly.

HYDRAULIC CHECKS

Before checking on the torque converter, transmission, and allied hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made:

Check oil level in transmission. This should be done with oil temperatures of 180 to 200° F. [82,2-93,3° C]. DO NOT ATTEMPT THESE CHECKS WITH COLD OIL. To bring the oil temperature to this specification it is necessary to either work the machine or "stall" out

the converter. Where the former means is impractical, the latter means should be employed as follows:

Engage shift levers in forward and high speed and apply brakes. Accelerate engine half to three-quarter throttle.

Hold stall until desired converter outlet temperature is reached. **CAUTION: FULL THROTTLE STALL SPEEDS FOR AN EXCESSIVE LENGTH OF TIME WILL OVERHEAT THE CONVERTER.**

LOW CLUTCH PRESSURE

Cause	Remedy
1. Low oil level.	1. Fill to proper level.
2. Clutch pressure regulating valve spool stuck open.	2. Clean valve spool and housing.
3. Faulty charging pump.	3. Replace pump.
4. Broken or worn clutch shaft or piston sealing rings.	4. Replace sealing rings.
5. Clutch piston bleed valve stuck open.	5. Clean bleed valves thoroughly.

LOW CONVERTER CHARGING PUMP OUTPUT

1. Low oil level.	1. Fill to proper level.
2. Suction screen plugged.	2. Clean suction screen.
3. Air leaks at pump intake hose and connections or collapsed hose. (R-32000 only)	3. Tighten all connections or replace hose if necessary.
4. Defective oil pump.	4. Replace pump.

OVERHEATING

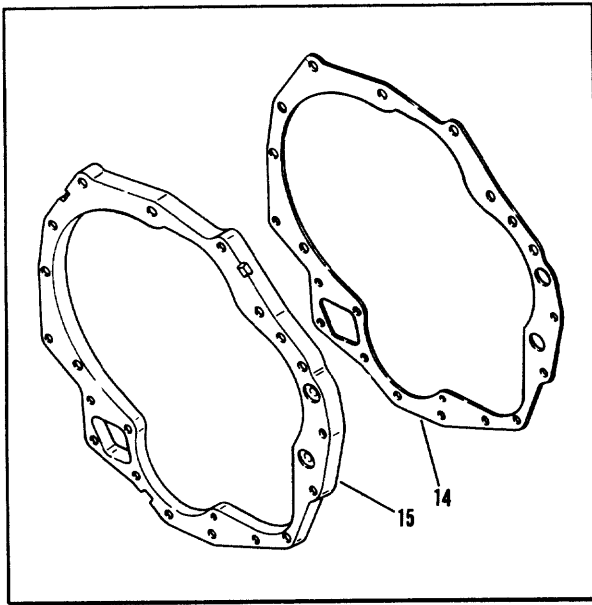
1. Worn oil sealing rings.	1. Remove, disassemble, and rebuild converter assembly.
2. Worn oil pump.	2. Replace.
3. Low oil level.	3. Fill to proper level.
4. Pump suction line taking air. (R-32000 only)	4. Check oil line connections and tighten securely.

NOISY CONVERTER

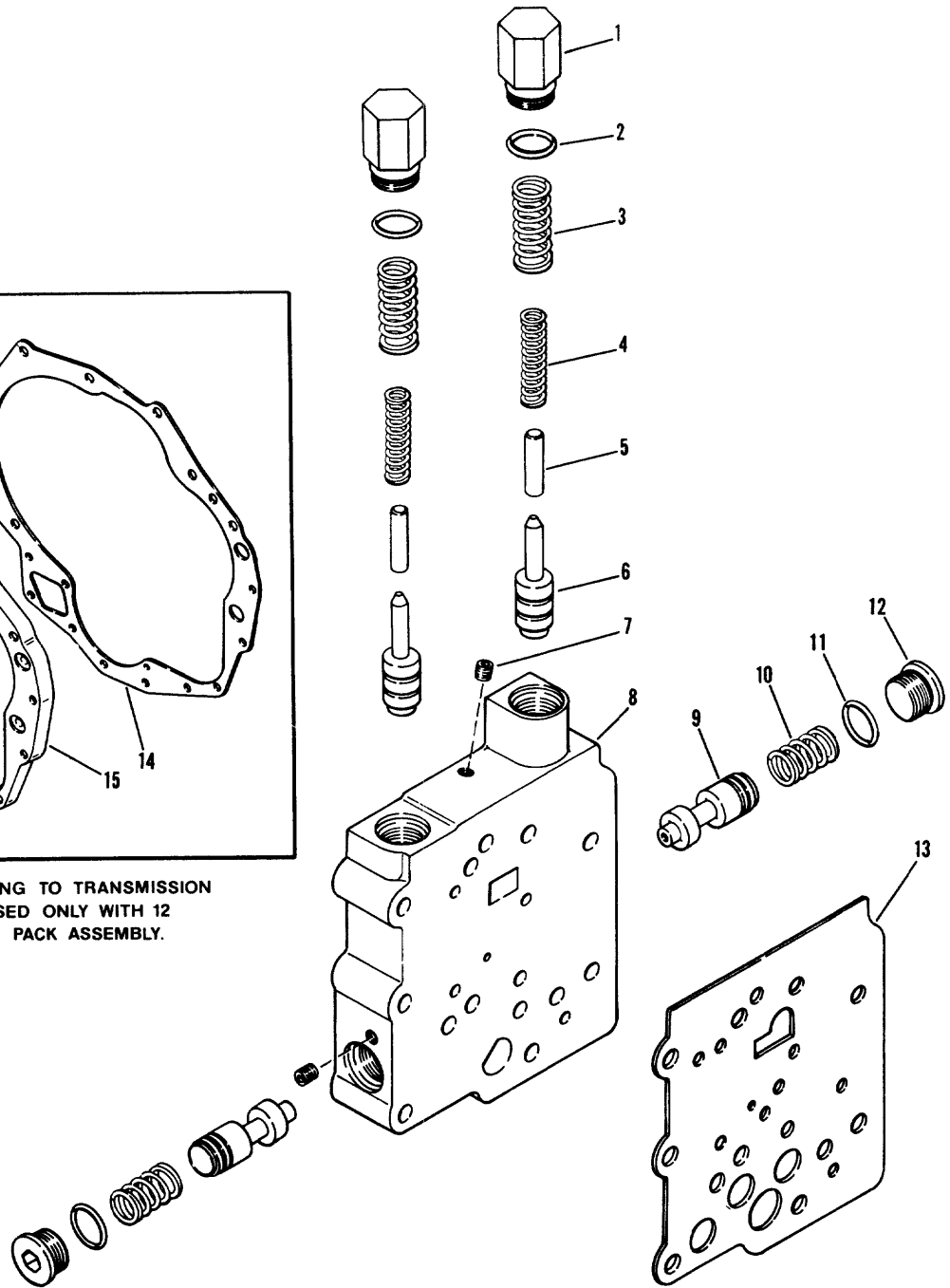
1. Worn coupling gears.	1. Replace.
2. Worn oil pump.	2. Replace.
3. Worn or damaged bearings.	3. A complete disassembly will be necessary to determine what bearing is faulty.

LACK OF POWER

1. Low engine RPM at converter stall.	1. Tune engine check governor.
2. See "Overheating" and make same checks.	2. Make corrections as explained in "Overheating."



CONVERTER HOUSING TO TRANSMISSION
CASE SPACER USED ONLY WITH 12
PLATE CLUTCH PACK ASSEMBLY.

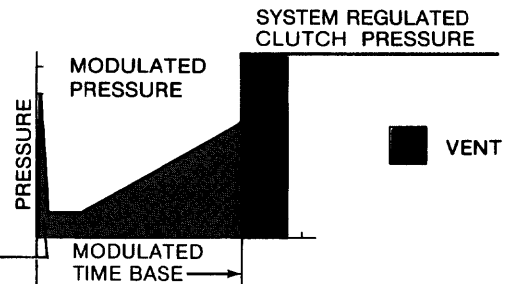
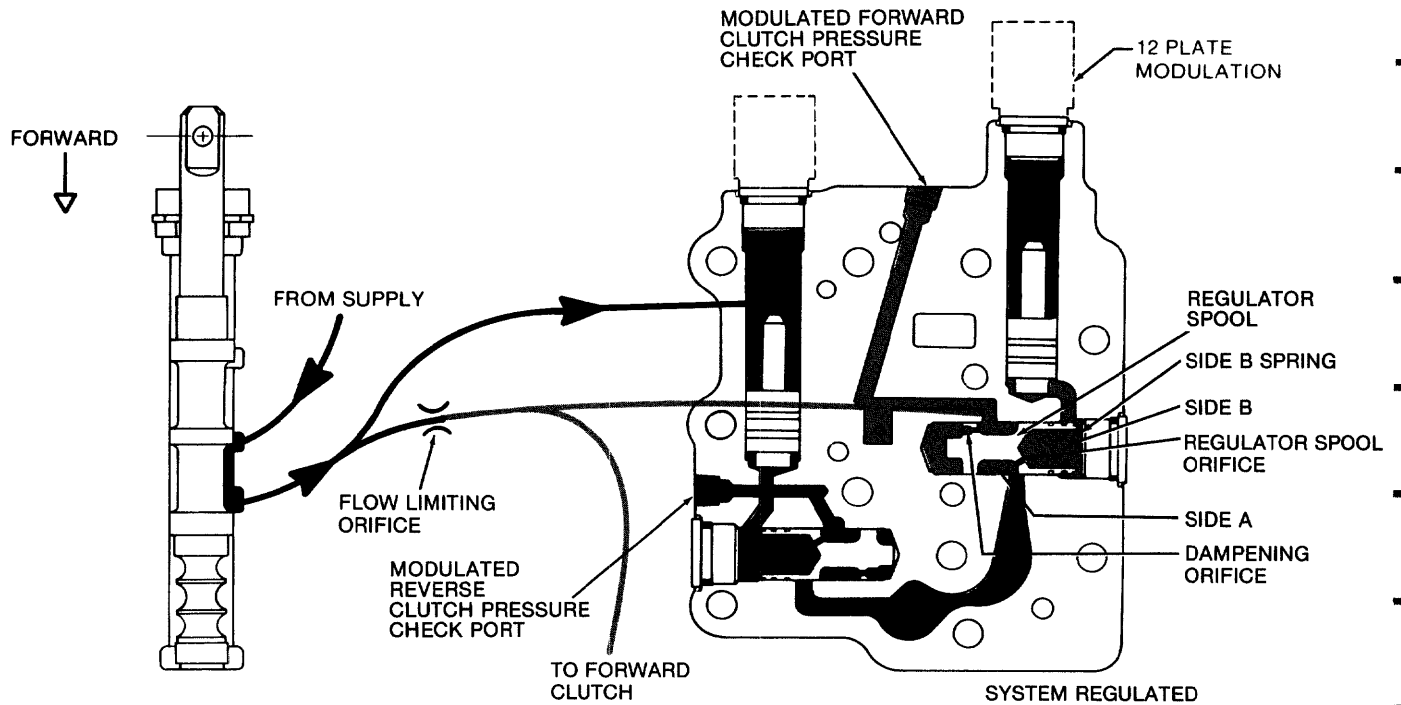


MODULATED VALVE ASSEMBLY

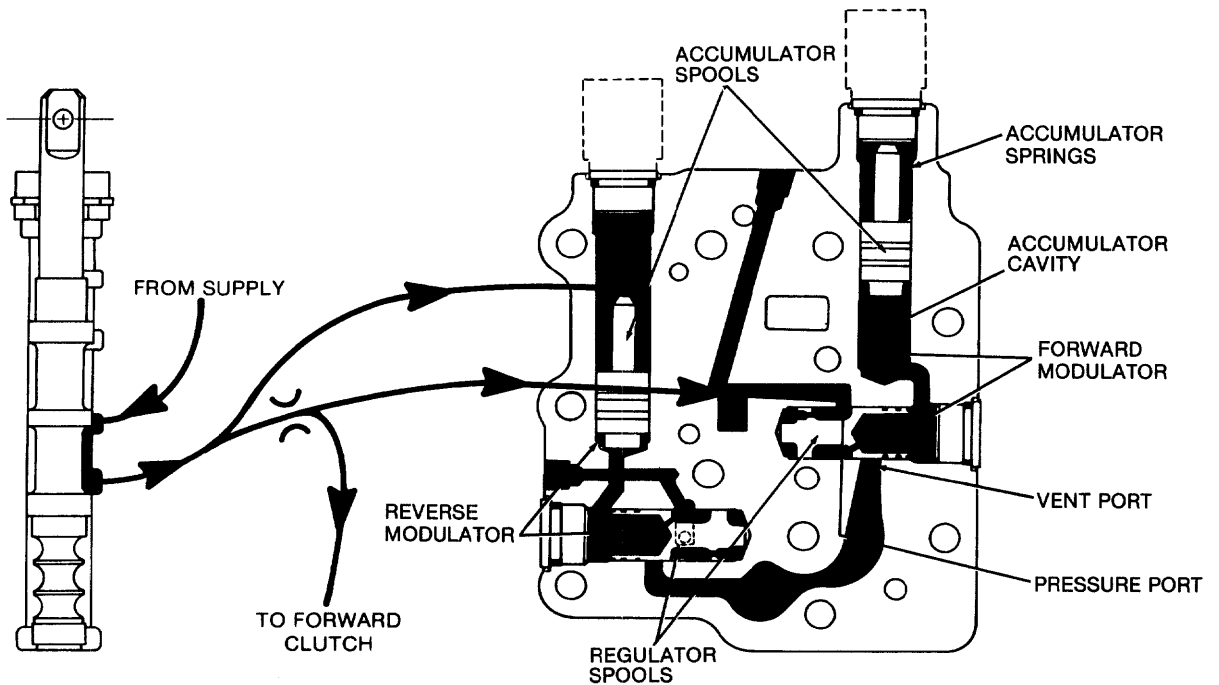
ITEM	DESCRIPTION	QTY.
1	Accumulator Valve Stop Plug	2
2	Accumulator Valve Stop Plug "O" Ring....	2
3	Accumulator Spring - Outer.....	2
4	Accumulator Spring - Inner.....	2
5	Accumulator Valve Pin.....	2
6	Accumulator Valve	2
7	Plug	2
8	Modulator Valve Housing	1

ITEM	DESCRIPTION	QTY.
9	Regulator Spool	2
10	Regulator Spring.....	2
11	Regulator Spool Stop Plug "O" Ring....	2
12	Regulator Spool Plug.....	2
13	Modulator Valve to Plate Gasket	1
14	Housing Spacer Gasket.....	
15	Housing Spacer	

32000 SERIES MODULATION



This pressure spike is time required for spools to react. The spike pressure is used to quickly fill the clutch pressure supply passages with oil.



THEORY OF OPERATION

TRANSMISSION MODULATOR VALVE OPERATIONAL DESCRIPTION

Both directional clutch assemblies are controlled by individual modulator valves. The pressure rise at side "A" of the regulator spool is the same as that applying the clutch piston. Supply flow to the clutch and modulator is limited by a flow limiting orifice. From this limited flow the regulator spool drains flow to the vent port. The regulator spool restricts flow through the vent port to build clutch pressure at a predetermined rate. Once the vent flow is shut off, only minimal flow passes through the flow limiting orifice to make up for normal spool and clutch leakages. Pressure on either side of the orifice is virtually identical and full regulated system pressure is applied at the clutch piston.

When forward direction is selected the oil under pressure enters the port on the "A" side of the regulator spool. This passes through the dampening orifice. The pressure force on the spool area shifts the spool to the right exposing the vent port. The time required to shift the regulator spool over to expose the vent port shows up as a pressure spike at the beginning of the pressure versus time chart.

The movement of the regulator spool is opposed by the regulator and accumulator springs. This provides an initial low pressure head of approximately 20 psi [137,9 Kpa] on the "A" side of the spool. This 20 psi [137,9 Kpa] is represented as a horizontal line on the pressure versus time chart immediately following the spike. Oil flows through the regulator spool orifice due to a pressure imbalance. Pressure at side "A" is constantly 10 psi [68,9 Kpa] higher than side "B" as a result of the added force of the side "B" spring.

The 10 psi [68,9 Kpa] supply through the regulator spool orifice gives a controlled flow rate. This controlled flow establishes the time it takes to fill the accumulated cavity.

As the accumulator cavity is filled, the accumulator spool is forced against the accumulator springs. As the springs compress their force increases causing the hydraulic pressure in the accumulator cavity and "B" side of the regulator spool to increase. Pressure on the "A" side of the regulator spool increases with the opposing force on the "B" side.

This causes the rising slope in the clutch pressure versus time chart. The rate of this rise is controlled by the accumulator spring force. Once the accumulator spool is stroked to its limit, pressure on "A" and "B" side of the regulator spool is balanced since no flow passes through the regulator spool orifice. The regulator spool spring pushes the regulator spool to the left shutting off the vent flow. The clutch and modulator pressure rapidly rise to the system regulated clutch supply pressure setting. This is the vertical line on the clutch pressure versus time chart.

The entire modulator sequence of events occurs in less than two seconds. The steady rise of clutch pressure increases the clutch driving torque which results in a smooth clutch application.

When forward direction is selected the reverse clutch and modulator are vented through the control valve to the transmission sump. The reverse accumulator cavity is vented back through the regulator spool orifice. To hasten the reset time of the accumulator, immediately preparing the transmission for a directional shift, full system regulated clutch supply pressure from the forward control valve is directed to the spring cavity of the reverse accumulator.

When reverse direction is selected the reverse clutch and modulator function through the same sequence of events as the forward clutch and modulator. This same sequence of events also applies to the lock-up modulators.

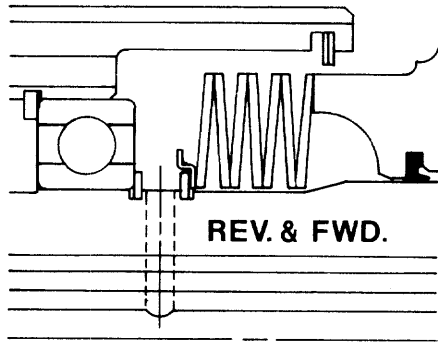
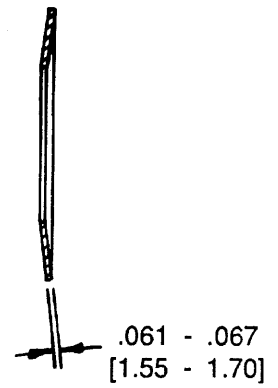


FIG. A



MODULATED FWD.
& REV. CLUTCHES

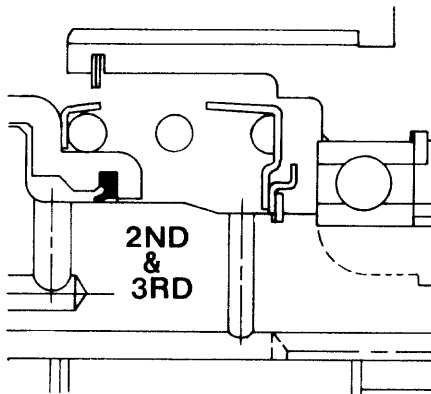


FIG. B

{ 2nd & 3rd & NON-
MODULATED FORWARD &
REVERSE CLUTCHES

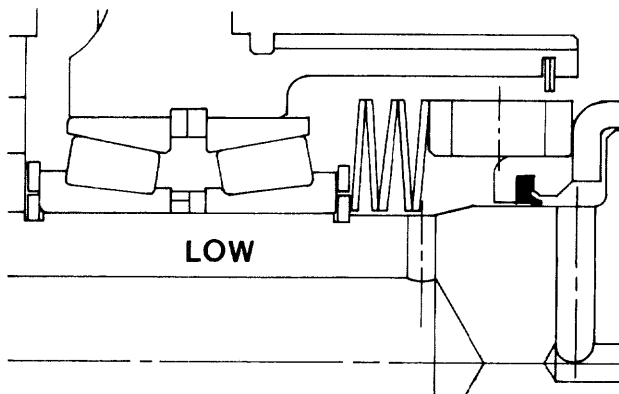
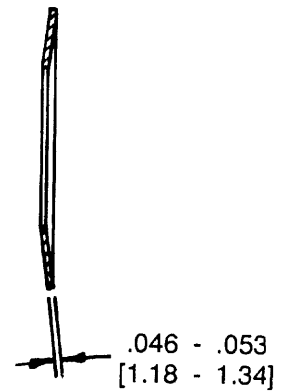


FIG. C



LOW (1st)
CLUTCH

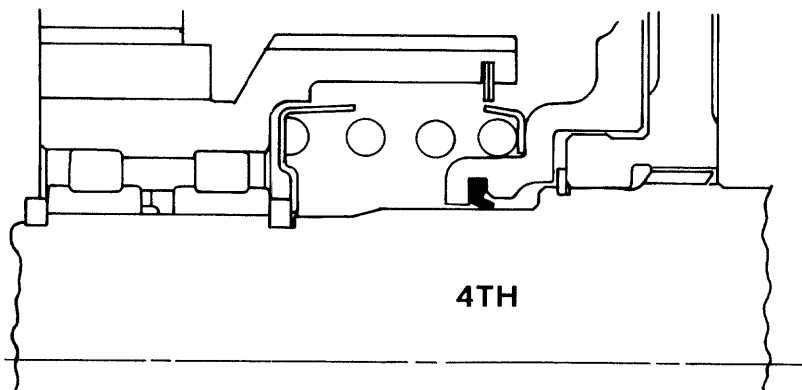


FIG. D
(4 SPEED ONLY)

16 SCREW RING GEAR INSTALLATION PROCEDURE (Non-Asbestos Ring Gear)

1. Remove all burrs from flywheel mounting face and pilot bores. Clean the torque converter ring gear flywheel mounting surface and the ring gear screw tapped holes with solvent. Dry thoroughly, being certain ring gear screw holes are dry and clean.
2. Check engine flywheel and housing or housing adaptor for conformance to standard S.A.E. No. 3 — SAE J927 and J1033 tolerance specifications for pilot bores size, pilot bores eccentricities and mounting face deviations. Measure and record engine crankshaft end play.
3. Install torque converter ring gear as shown.

NOTE: Assembly of the ring gear must be completed within a fifteen minute period from start of screw installation. The screws are prepared with an epoxy coating which begins to harden after installation in the flywheel mounting holes. If not tightened to proper torque within the fifteen minute period insufficient screw clamping tension will result.

4. Install backing ring and sixteen (16) special screws to approximately .06 inch [1,5 mm] of seated position. It is permissible to use a power wrench for this installation phase. With a calibrated torque wrench tighten screws 30 to 33 pounds feet of torque [40,7 - 44,7 N.m].

To obtain maximum effectiveness of the special screw's locking feature, a minimum time period after screw installation of twelve (12) hours is suggested before engine start-up.

The special screw is to be used for **ONE** installation only. If the screw is removed for any reason it **MUST BE REPLACED**. It is recommended that the epoxy left in the flywheel hole be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a **NEW** screw for re-installation.

5. Assemble torque converter to engine flywheel by sliding converter into position by hand before fastening housing attachment screws. This may require more than one trial to match the drive gear teeth. Pulling the converter into position with housing attachment bolts is not recommended.
6. Measure engine crankshaft end play after assembly of torque converter. This value must be within one thousandth (.001) of an inch [0,0254mm] of end play recorded (in Paragraph #2) before assembly of torque converter.

802553 — 1.5 INCH [38,1] 16 SCREW RING GEAR KIT

1	249341	Torque Converter Ring Gear
16	236288	Ring Gear Screw 1.5 Inch [38,1]
1	802555	Installation Instruction Sheet

802554 — 1.5 INCH [38,1] 16 SCREW RING GEAR KIT

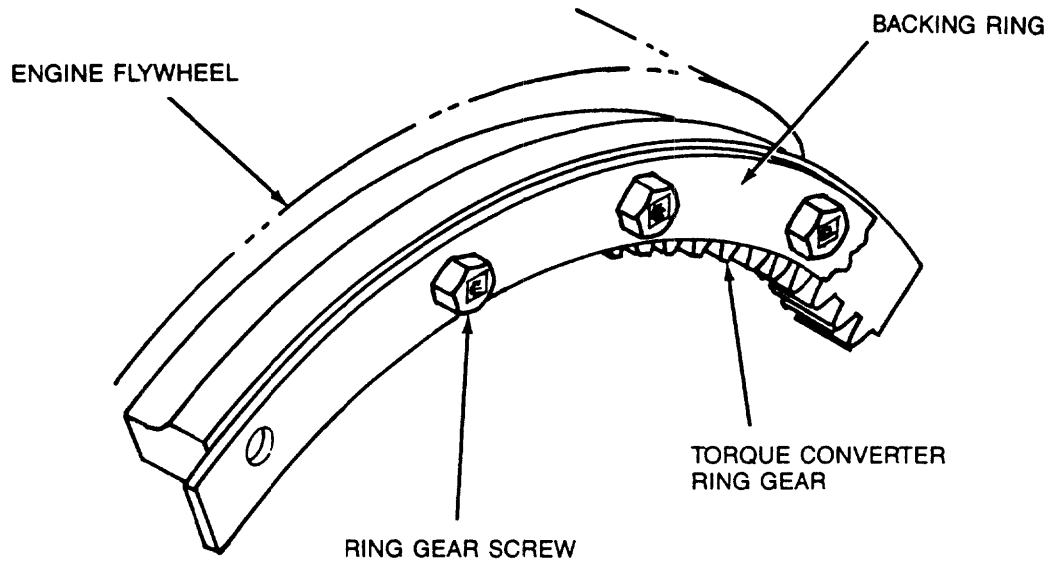
1	249341	Torque Converter Ring Gear
16	236288	Ring Gear Screw 1.5 Inch [38,1]
1	243767	Backing Ring
1	802555	Installation Instruction Sheet

243767 Backing Ring not included in 802553 Ring Gear Kit. Must be Ordered Separately.

Dimensions are in inches — Dimensions in [] are mm.

SEE PAGE 42 FOR INSTALLATION ILLUSTRATIONS

SEE PAGE 56 FOR 32 BOLT INSTALLATION



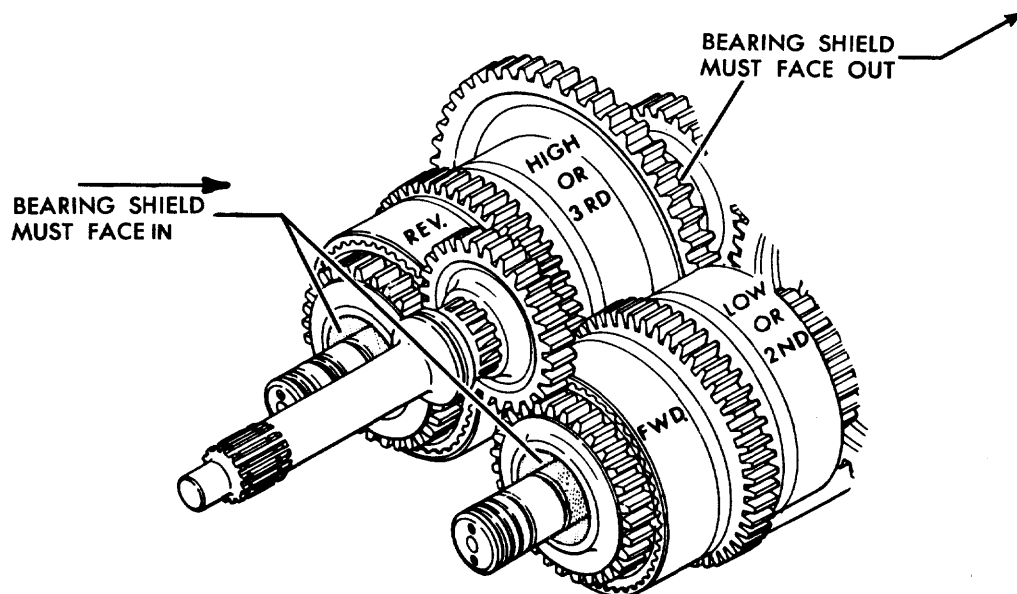
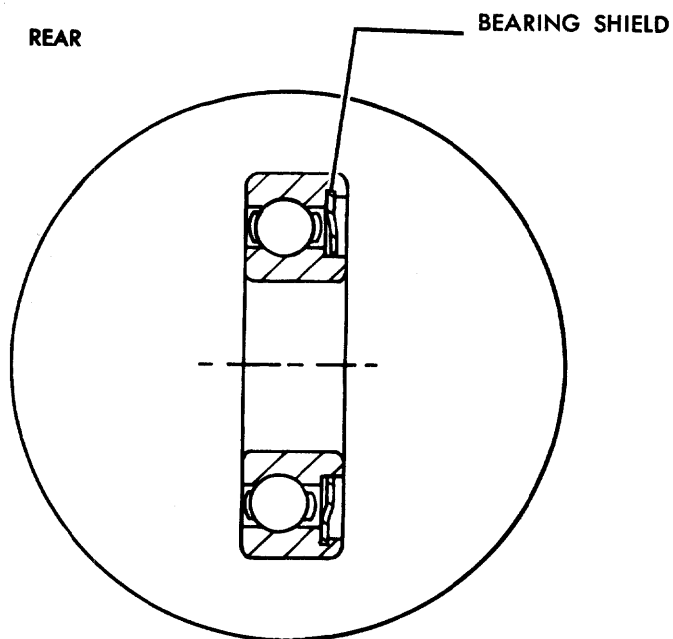
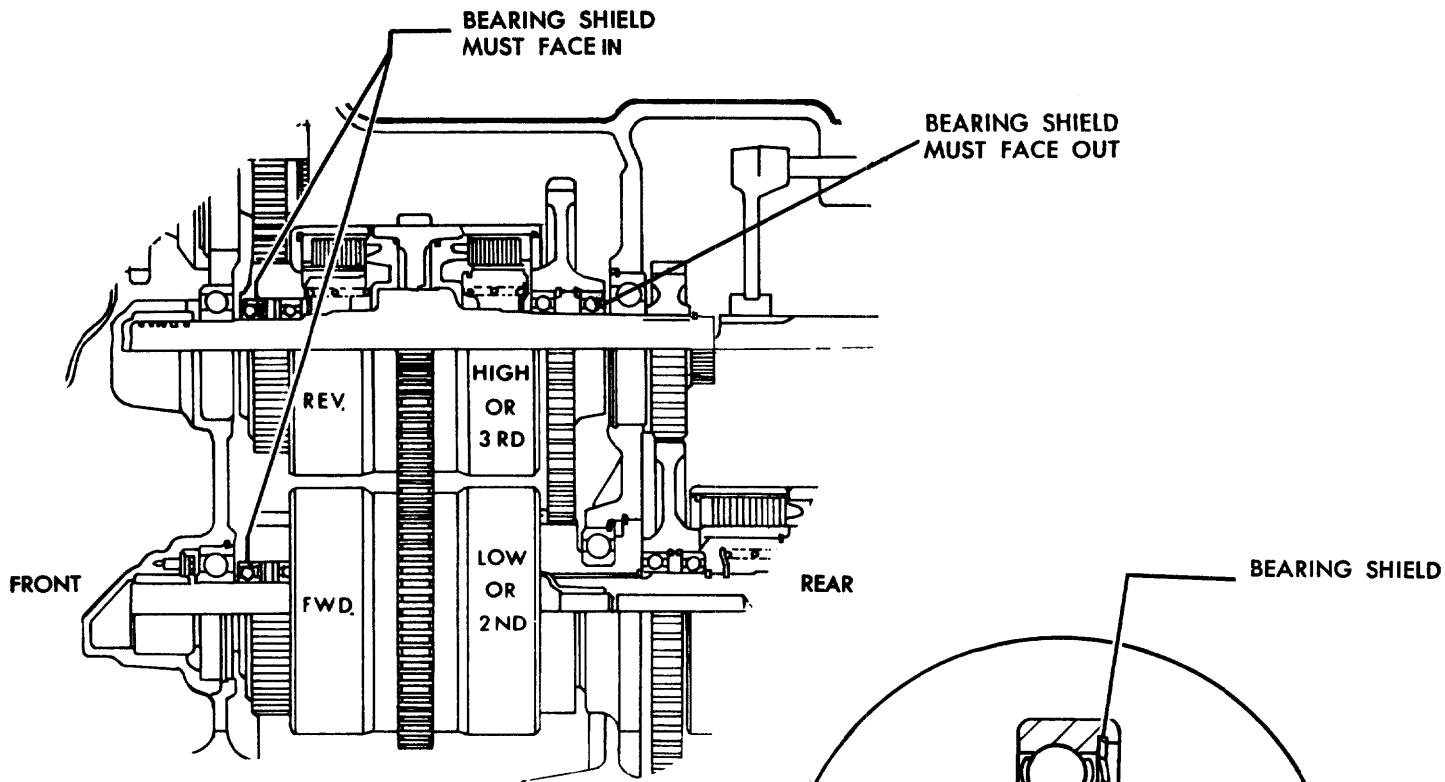
RING GEAR SCREW
(16) 236288 1.500 [38,1]

ENGINE FLYWHEEL

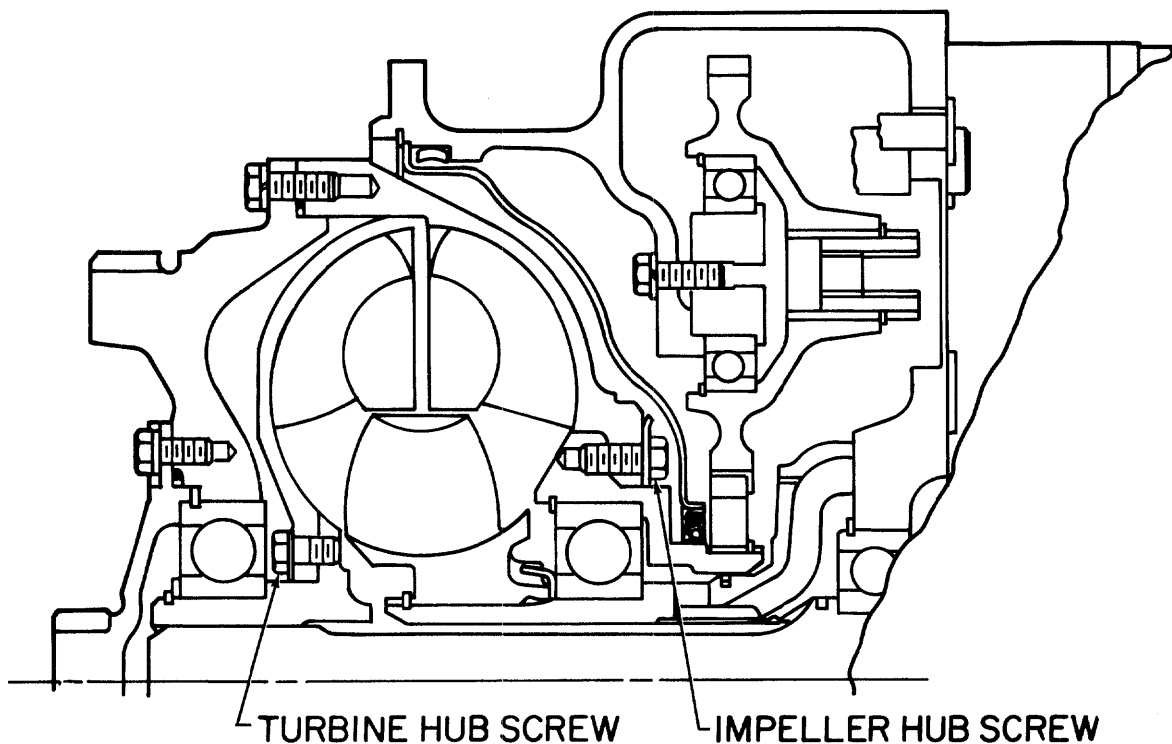
SEE PAGE 41
FOR INSTALLATION
PROCEDURE AND
BOLT TORQUE

BACKING RING
243767

TORQUE CONVERTER
RING GEAR 249341

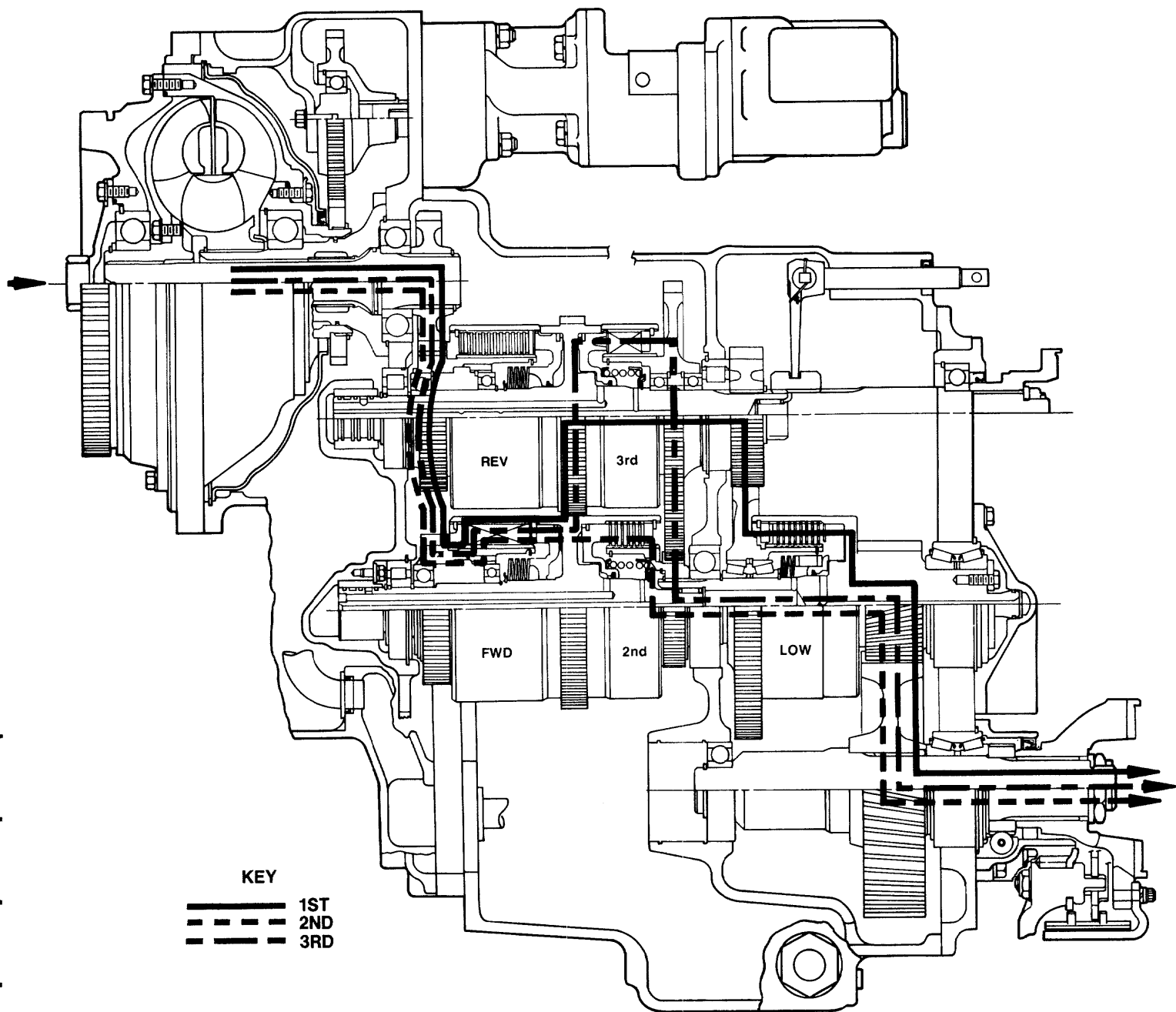


SHIELDED BEARING INSTALLATION

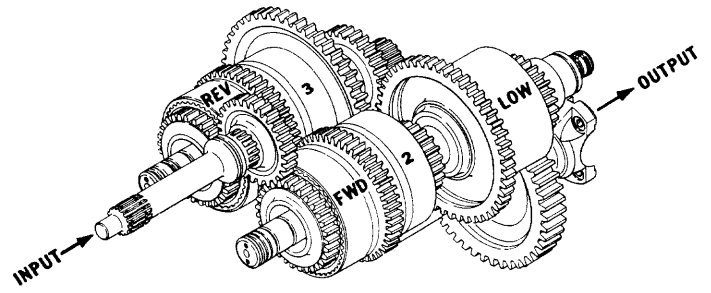
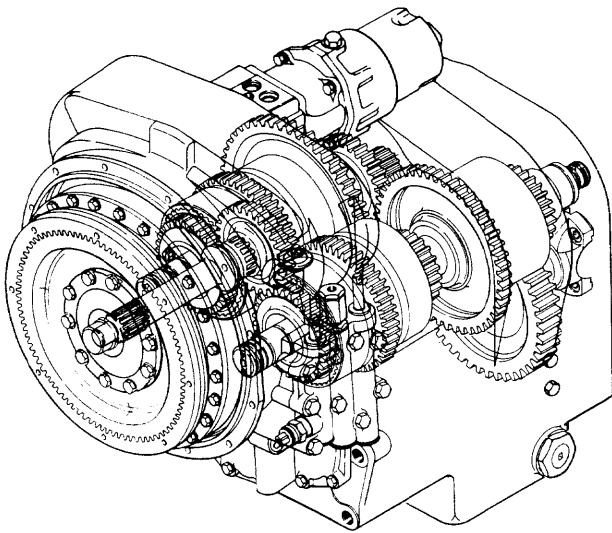


**IMPELLER HUB & TURBINE HUB ASSEMBLY WITH BACKING
RING AND SPECIAL SELF LOCKING SCREWS.**

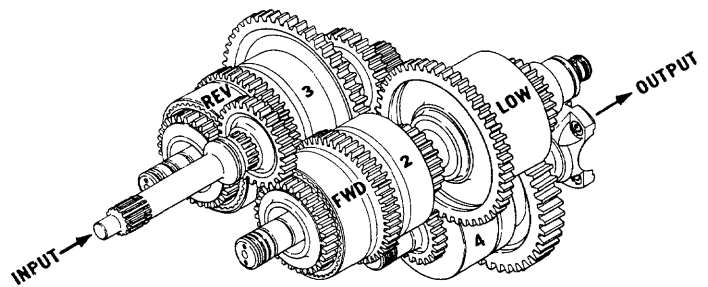
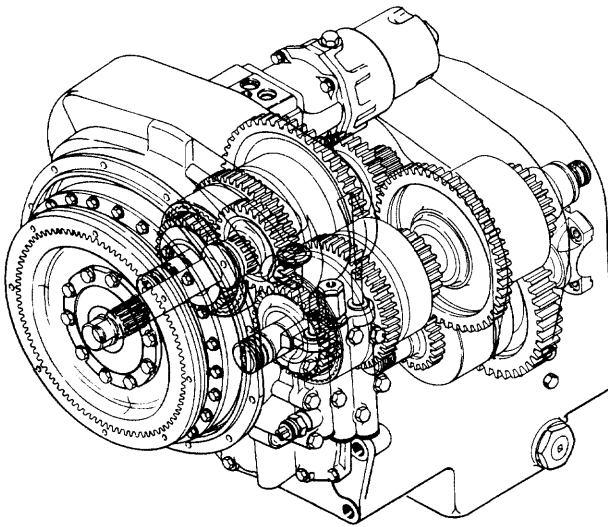
1. CLEAN HUB MOUNTING SURFACE AND TAPPED HOLES WITH SOLVENT. DRY THOROUGHLY BEING CERTAIN TAPPED HOLES ARE DRY AND CLEAN.
2. INSTALL BACKING RING AND SPECIAL SCREWS TO APPROXIMATELY .06 INCH [1,5] OF SEATED POSITION. WITH A CALIBRATED TORQUE WRENCH, TIGHTEN SCREWS 40 TO 45 LBS. FT. TORQUE [54,3-61,0 N.m]. NOTE: ASSEMBLY OF IMPELLER OR TURBINE HUB MUST BE COMPLETED WITHIN A FIFTEEN MINUTE PERIOD FROM START OF SCREW INSTALLATION. THE SCREWS ARE PREPARED WITH A COATING WHICH BEGINS TO HARDEN AFTER INSTALLATION IN THE HUB HOLES. IF NOT TIGHTENED TO PROPER TORQUE WITHIN THE FIFTEEN MINUTE PERIOD, INSUFFICIENT SCREW CLAMPING TENSION WILL RESULT. THE SPECIAL SCREW IS TO BE USED FOR ONE INSTALLATION ONLY. IF THE SCREW IS REMOVED FOR ANY REASON IT MUST BE REPLACED. THE COMPOUND LEFT IN THE HUB HOLES MUST BE REMOVED WITH THE PROPER TAP AND CLEANED WITH SOLVENT. DRY HOLE THOROUGHLY AND USE A NEW SCREW FOR REINSTALLATION.



32000 3 SPEED TRANSMISSION

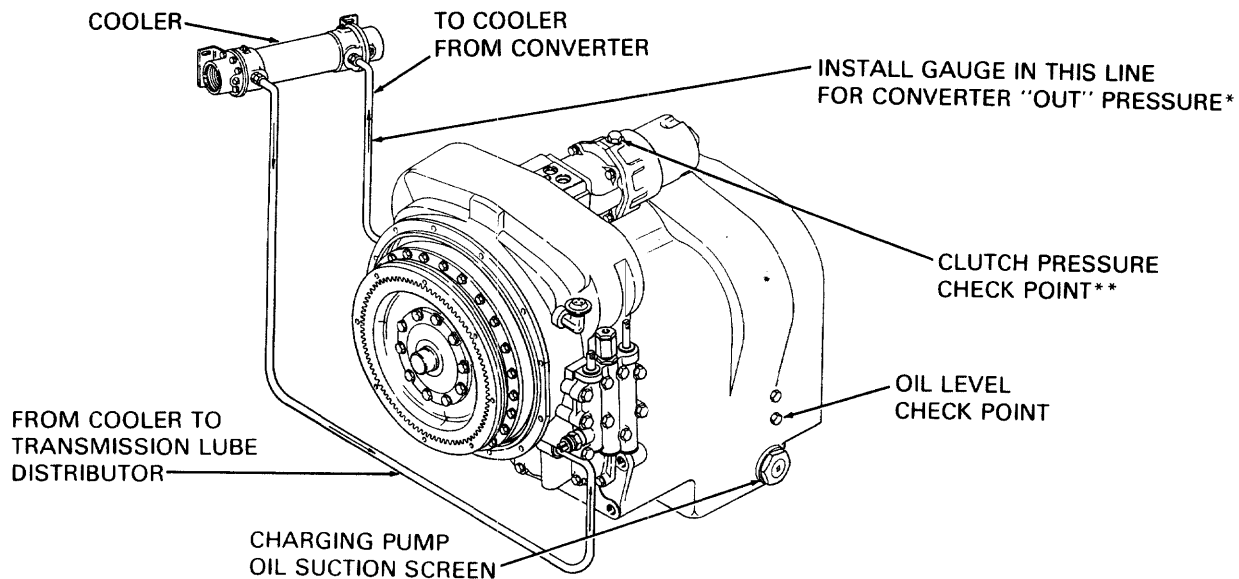


3 SPEED

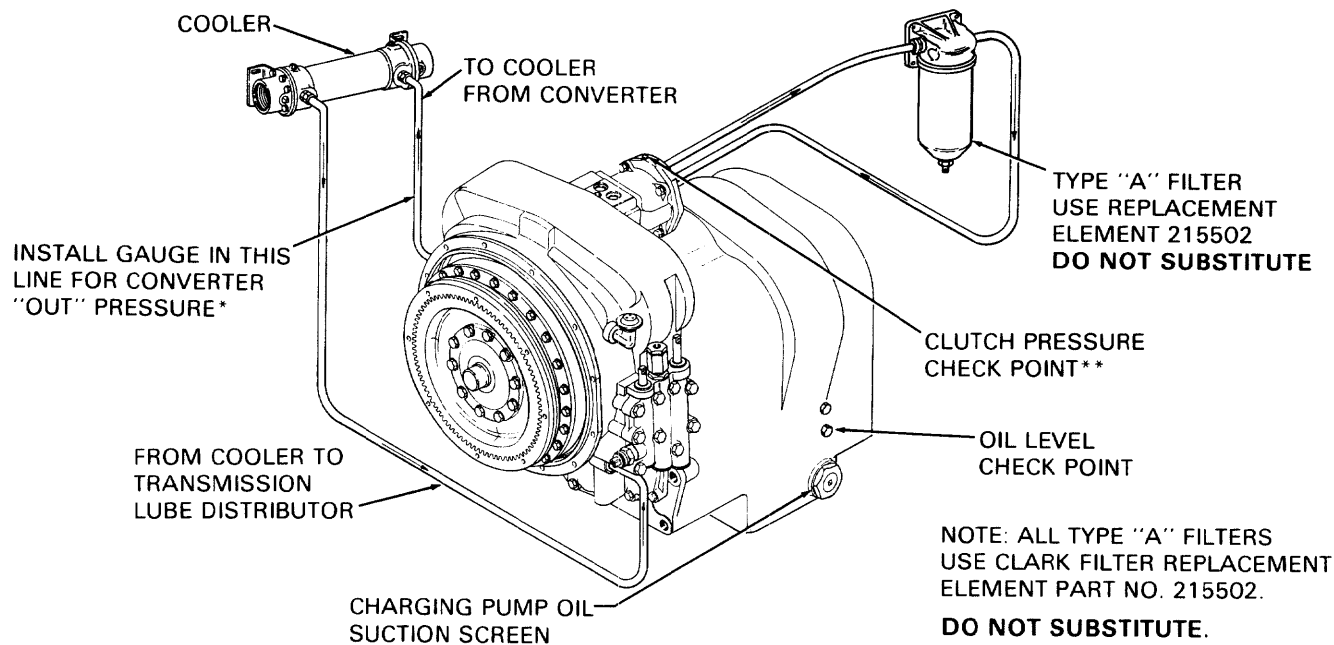


4 SPEED

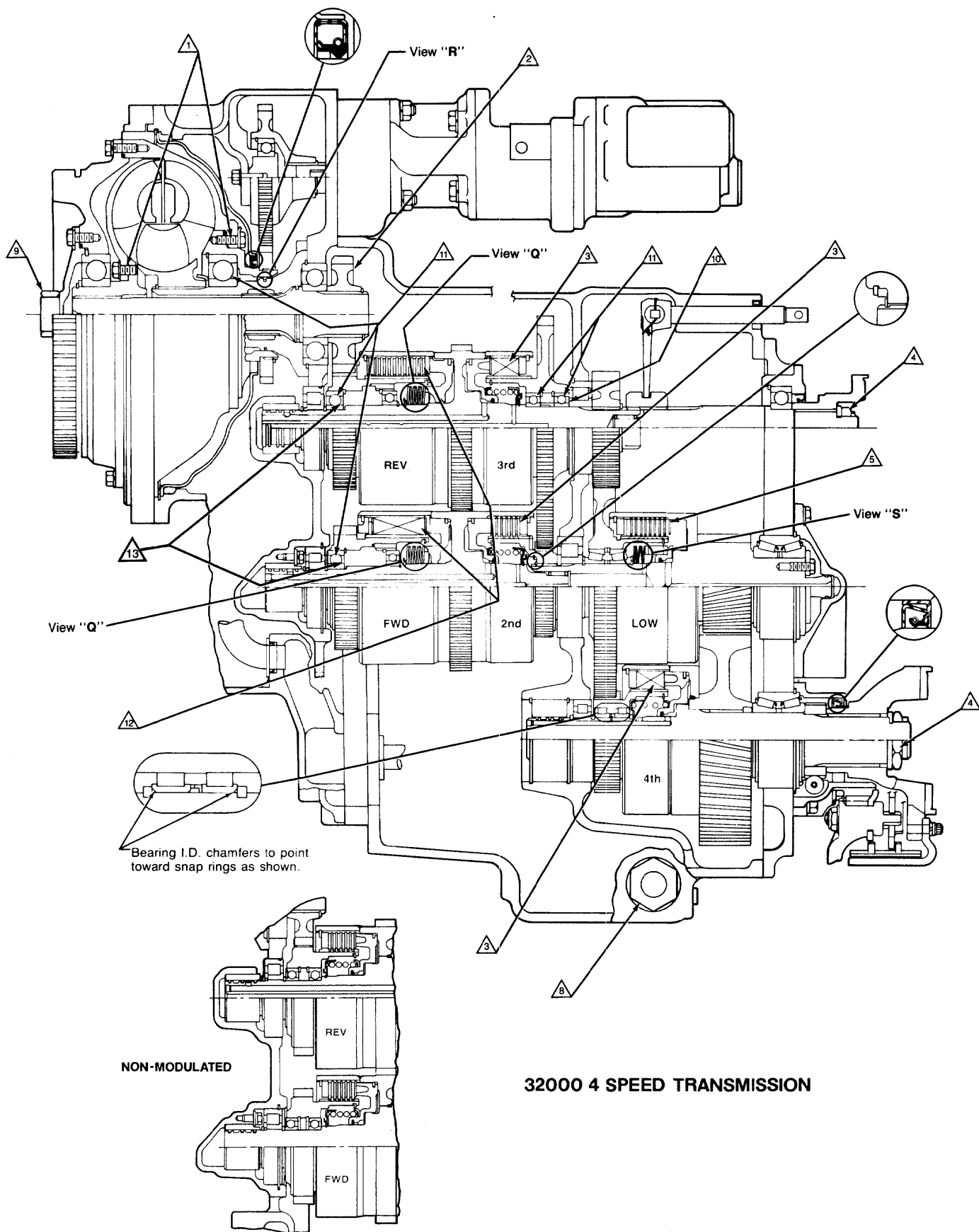
**32000 SERIES - 3 AND 4 SPEED
CLUTCH & GEAR ARRANGEMENT
(SHORT DROP OUTPUT)**



**SHORT DROP
32000 SERIES PLUMBING DIAGRAM**



**SHORT DROP
32000 SERIES PLUMBING DIAGRAM
(WITH REMOTE FILTER)**

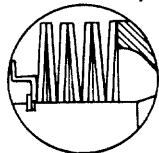


1. Impeller Hub and Turbine Hub Assembly with Backing Ring and Special Self Locking Screws.
1. Clean hub mounting surface and tapped holes with solvent. Dry thoroughly being certain tapped holes are dry & clean.
2. Install backing ring and special self locking screws.
Tighten screws 40 to 45 Lbs. Ft. [54,3-61,0 N·m]
Note: Assembly of hub must be complete within a fifteen minute period from start of screw installation. The special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced. The epoxy left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.
2. Gear to be assembled with long hub length to this side.
3. Two clutches, 6-outer steel plates, 6-inner friction plates. Assemble alternately, starting with outer steel plate.
4. See Elastic Stop Nut Torque Chart
5. Low clutch, 9-outer steel plates, 9-inner friction plates. Assemble alternately, starting with outer steel plate.
8. Tighten oil screen ass'y. 10 to 15 Lbs. Ft. [13,6-20,0 N·m]

9. Heat nose bushing to 200° F° (93°C) before ass'y. of bushing to cover.
10. Bearing shield out
11. Must be loose internal fit bearings, No. "3" etched on bearing.
12. (12 Plate Modulation) Two clutches, 12-outer steel plates, 12-inner friction plates. Assemble alternately, starting with outer steel plate.
13. Bearing shield in
- Notes
- A. - Use Permatex & Crane Sealer only where specified.
- B. - All lead in chamfers for oil seals, piston rings & "O" rings must be smooth & free from burrs. Inspect at ass'y.
- C. - Lubricate all piston ring grooves & "O" rings with oil before ass'y.
- D. - Apply very light coat of Permatex No. 2 to O.D. of all oil seals before ass'y.
- E. - After assembly of parts using Permatex or Crane sealer, there must not be any free or excess material that could enter the oil circuit.
- F. - Apply light coat of Crane Sealer to all pipe plugs.
- G. - Apply a thin coating of grease between seal lips on lip type seals prior to ass'y.
- H. - Apply light coat of Permatex No. 2 to all thru hole stud threads.

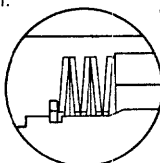
NOTE: The friction discs in the low clutch has a higher co-efficient rating than the friction discs in the other clutches, therefore the discs must not be mixed. The low clutch inner disc can be identified by an "X" stamped on one side of the inner teeth. The low clutch inner disc also has a strip of non-soluble yellow paint sprayed on the outer edge of the disc.

View "Q" 2 Places
Modulation only



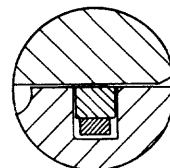
Low Clutch Return Springs.
Concave side of first Belleville washer to be placed against clutch piston. Remaining four washers to be stacked alternately reversed as shown.

View "S"



Forward & Reverse Clutch Return Springs.
Concave side of first Belleville washer to be placed against clutch piston. Remaining six washers of each clutch to be stacked alternately reversed as shown.

View "R"





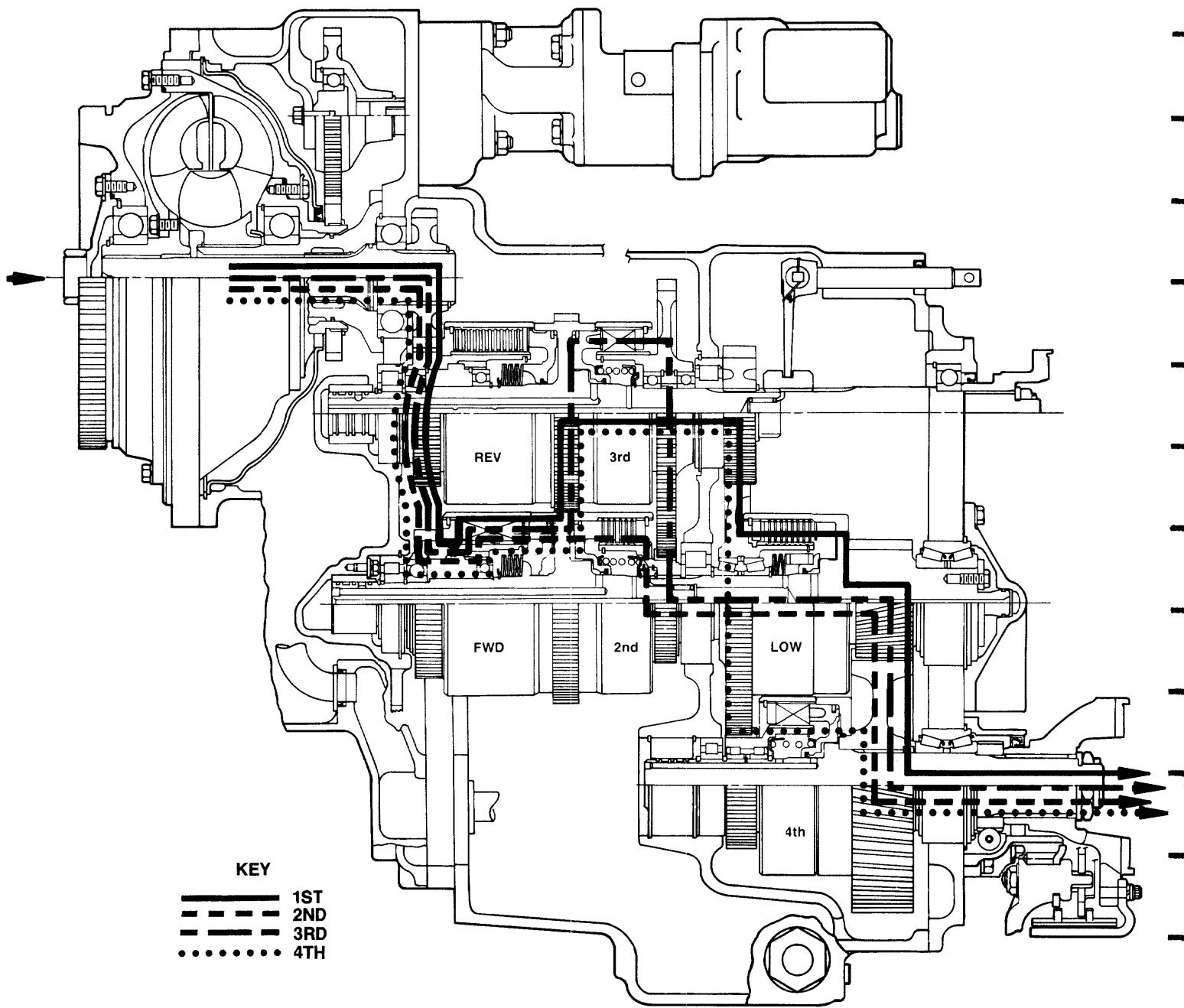
Enlarged view of Piston Ring & Expander
Note: Expander gap to be approx. 180° from ring hook joint to aid ring assembly.

ELASTIC STOP NUT TORQUE

THREAD SIZE	LB.-FT.	[N·m]
1" - 20	150 - 200	[203,4 - 271,1]
1 1/4" - 18	200 - 250	[271,2 - 338,9]
1 1/2" - 18	300 - 350	[406,8 - 474,5]
1 3/4" - 12	400 - 450	[542,4 - 610,1]

NOTE: Metric dimensions shown in brackets [].

TORQUE SPECIFICATION FOR LUBRICATED OR PLATED SCREWS AND NUTS							
NOMINAL SIZE	GRADE 5 				GRADE 8 		
	FINE THREAD		COARSE THREAD		FINE THREAD		COARSE THREAD
	lb-ft	[N·m]	lb-ft	[N·m]	lb-ft	[N·m]	lb-ft [N·m]
.2500	9-11	[12-15]	8-10	[11-14]	11-13	[15-18]	9-11 [12-15]
.3125	16-20	[22-27]	12-16	[16-22]	28-32	[38-43]	26-30 [35-41]
.3750	26-29	[35-39]	23-25	[31-34]	37-41	[50-56]	33-36 [45-49]
.4375	41-45	[56-61]	37-41	[50-56]	58-64	[79-87]	52-57 [71-77]
.5000	64-70	[87-95]	57-63	[77-85]	90-99	[122-134]	80-88 [108-119]
.5625	91-100	[123-136]	82-90	[111-122]	128-141	[174-191]	115-127 [156-172]
.6250	128-141	[174-191]	113-124	[153-168]	180-198	[224-268]	159-175 [216-237]
.7500	223-245	[302-332]	200-220	[271-298]	315-347	[427-470]	282-310 [382-420]



32000 4 SPEED TRANSMISSION

4th SPEED CLUTCH DISASSEMBLY (4 Speed Transmission Only)

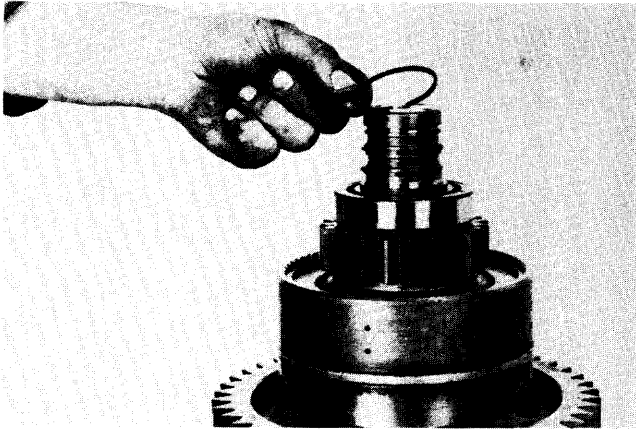


Figure 183

Remove clutch shaft oil sealing rings.

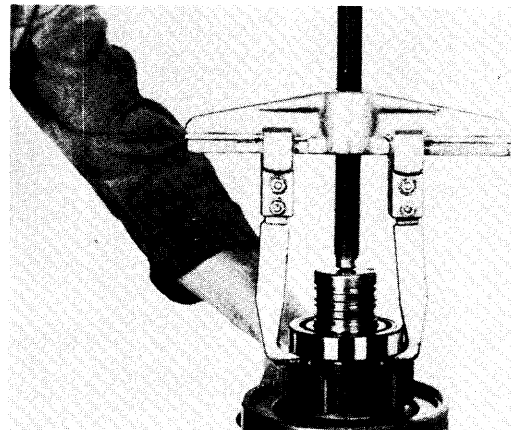


Figure 186

Remove outer bearing.

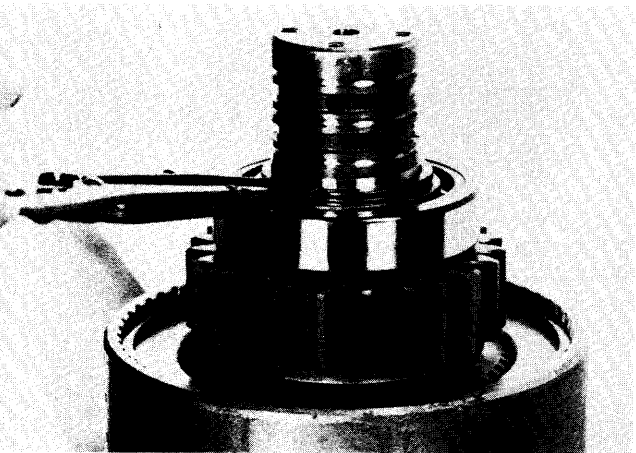


Figure 184

Remove front bearing retainer ring.



Figure 187

Remove 4th gear outer bearing retainer ring.

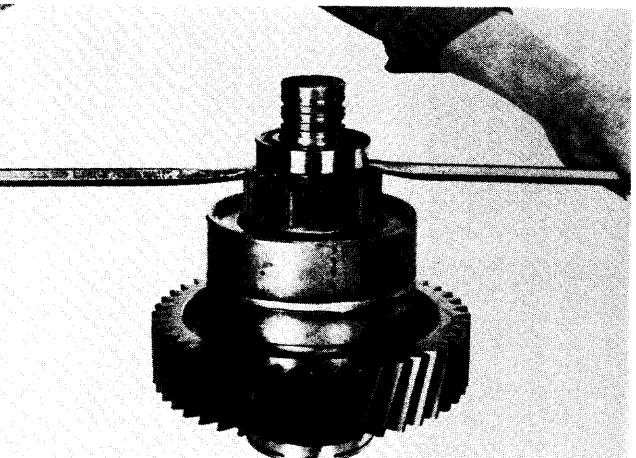


Figure 185

Pry front bearing to accommodate bearing puller.

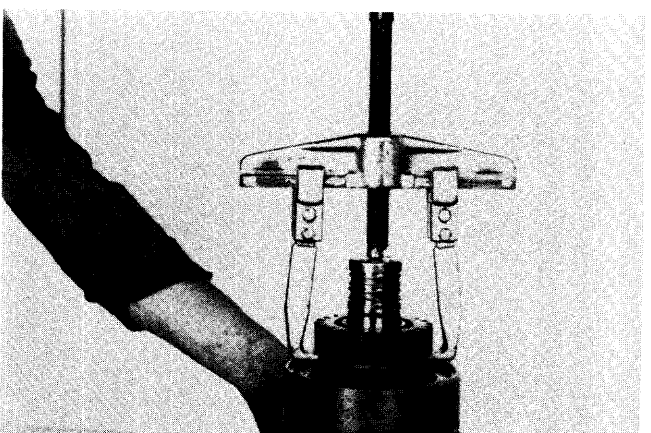


Figure 188

Pry 4th gear up to accommodate gear puller. Remove 4th gear.

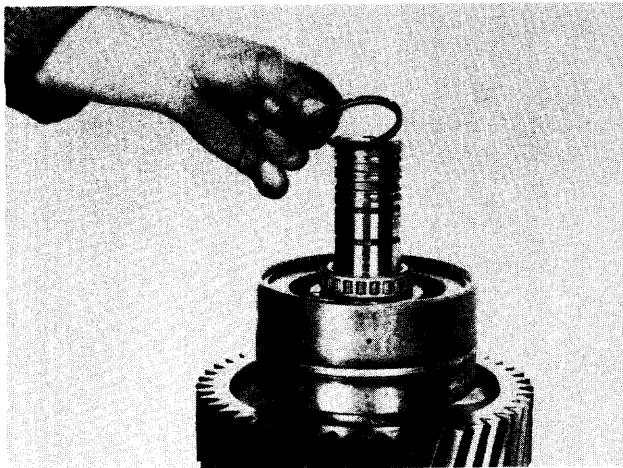


Figure 189

Remove bearing spacer.

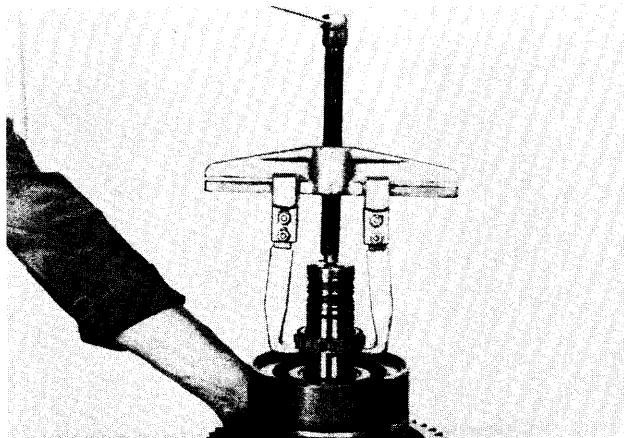


Figure 190

Remove 4th gear inner bearing. Remove end plate retainer ring and end plate. Remove inner and outer clutch discs. Compress spring retainer washer. Remove spring retainer snap ring. Release tension on spring retainer. Remove snap ring, spring retainer, return spring and clutch piston.

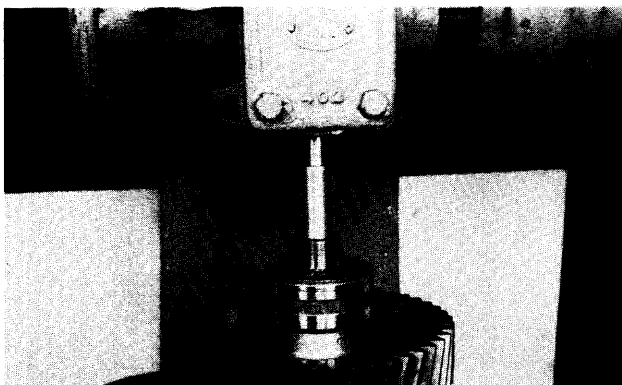


Figure 191

If rear bearing, shaft or output gear and clutch drum are to be replaced, press shaft from rear bearing and output gear.

4th SPEED CLUTCH REASSEMBLY

Press output gear and clutch drum assembly on output shaft. Press output shaft gear spacer in undercut in output gear.

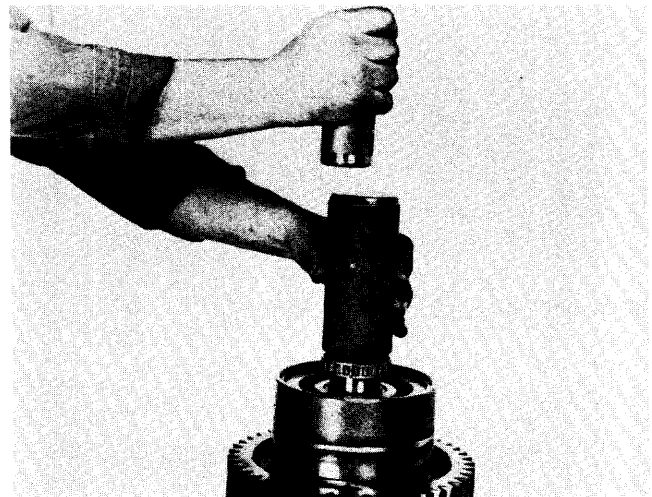


Figure 192

Install piston, and piston return spring. See page 40, Fig. D. Install inner and outer discs as explained in Fig. 87 & 88. Install 4th speed gear inner bearing. **NOTE:** Bearing Part Number must go down. See Figure 195.

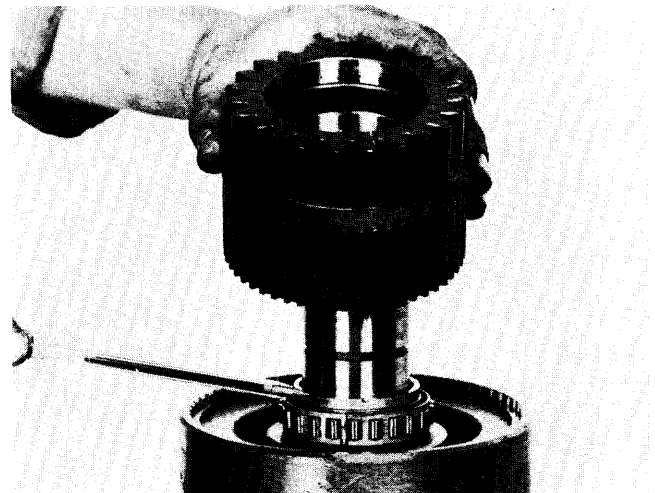


Figure 193

Install bearing spacer between inner and outer 4th speed gear bearings. Install 4th speed gear into clutch drum. Align splines on clutch gear with internal teeth of friction discs. Tap gear into position. Do not force this operation. Gear splines must be in full position with internal teeth of all friction discs.

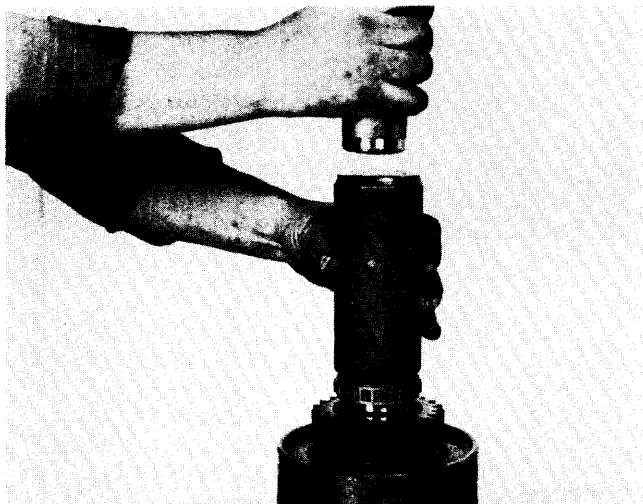


Figure 194

Install 4th speed gear outer bearing. **NOTE:** Bearing Part Number must go up. See Figure 195. It is recommended a rubber band be used to hold outer bearing rollers in position when installing bearing.

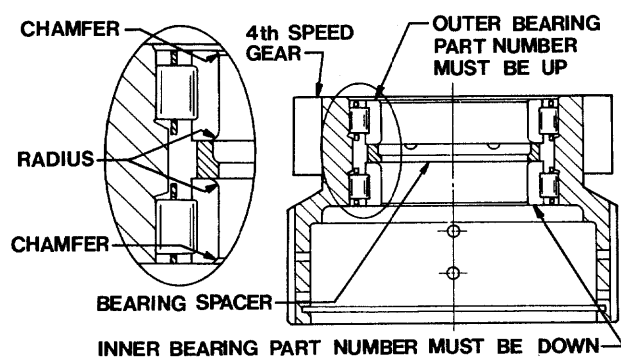


Figure 195

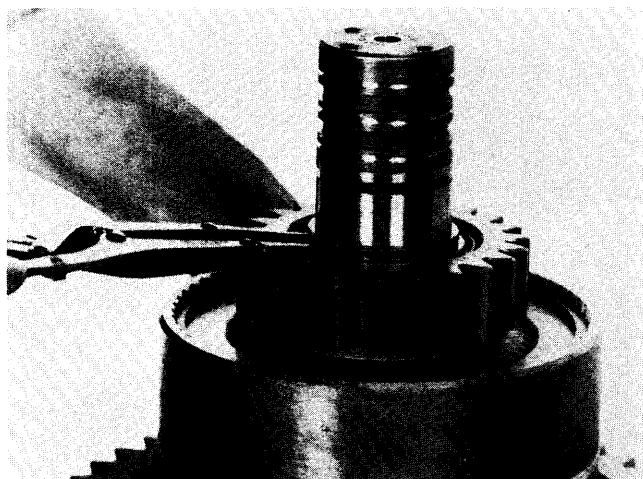


Figure 196

Install outer bearing retainer ring.

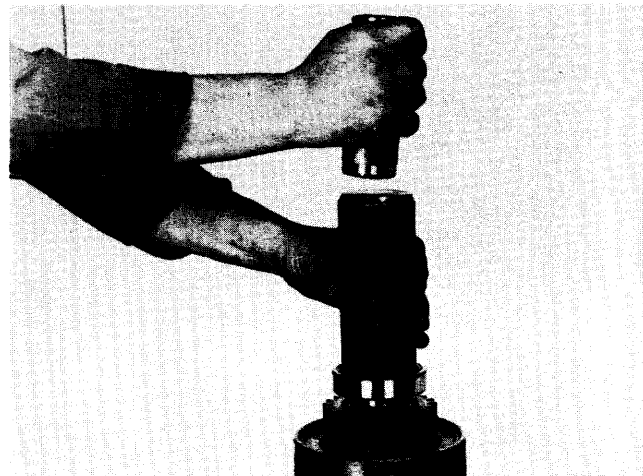


Figure 197

Install clutch shaft front bearing.

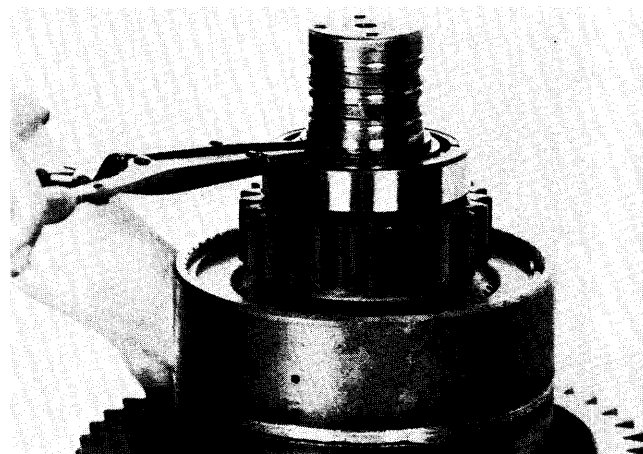


Figure 198

Install bearing retainer ring.

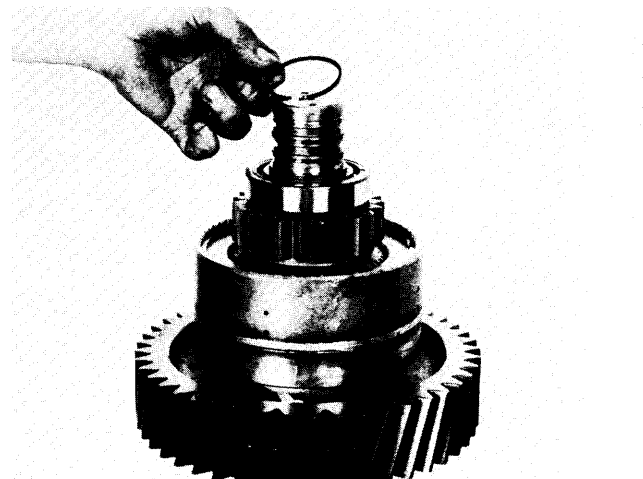


Figure 199

Install clutch shaft oil sealing rings.

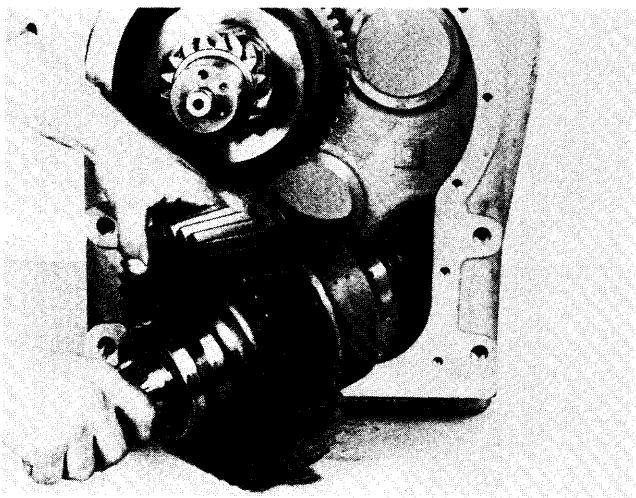
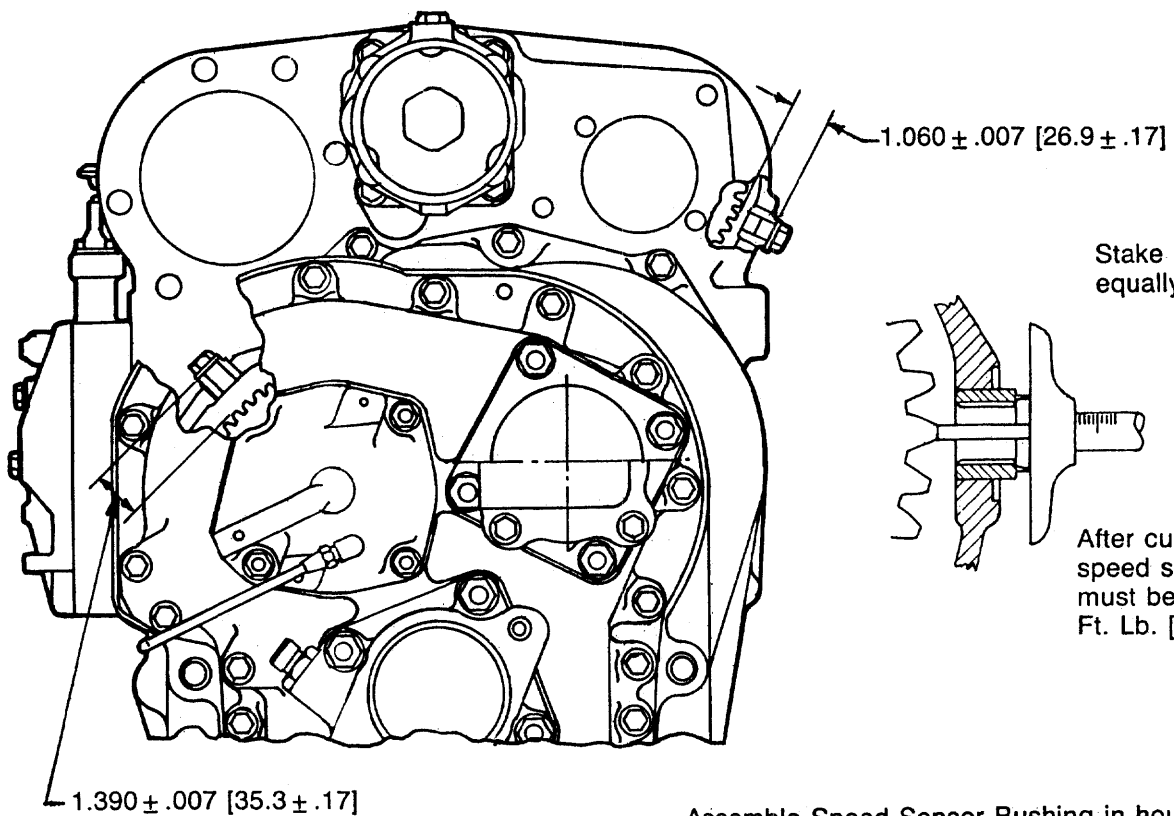


Figure 200

Install output shaft and 4th speed clutch assembly in transmission housing. Refer to Figure 121 for remainder of transmission reassembly.



REAR VIEW

Assemble Speed Sensor Bushing in housing to specified dimension with Loctite 262 and stake (3) three places.

SPEED SENSOR BUSHING INSTALLATION

32 SCREW RING GEAR INSTALLATION PROCEDURE (Non-Asbestos Ring Gear)

1. Remove all burrs from flywheel mounting face and pilot bores. Clean the torque converter ring gear flywheel mounting surface and the ring gear screw tapped holes with solvent. Dry thoroughly, being certain ring gear screw holes are dry and clean.
2. Check engine flywheel and housing or housing adaptor for conformance to standard S.A.E. No. 3 — SAE J927 and J1033 tolerance specifications for pilot bores size, pilot bores eccentricities and mounting face deviations. Measure and record engine crankshaft end play.
3. Install torque converter ring gear as shown.

NOTE: Assembly of the ring gear must be completed within a fifteen minute period from start of screw installation. The screws are prepared with an epoxy coating which begins to harden after installation in the flywheel mounting holes. If not tightened to proper torque within the fifteen minute period insufficient screw clamping tension will result.

4. Install backing ring and thirty-two (32) special screws to approximately .06 inch [1,5 mm] of seated position. It is permissible to use a power wrench for this installation phase. With a calibrated torque wrench tighten screws 23 to 25 pounds feet of torque [31,2 - 33,8 N.m].

To obtain maximum effectiveness of the special screw's locking feature, a minimum time period after screw installation of twelve (12) hours is suggested before engine start-up.

The special screw is to be used for **ONE** installation only. If the screw is removed for any reason it **MUST BE REPLACED**. It is recommended that the epoxy left in the flywheel hole be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a **NEW** screw for re-installation.

5. Assemble torque converter to engine flywheel by sliding converter into position by hand before fastening housing attachment screws. This may require more than one trial to match the drive gear teeth. Pulling the converter into position with housing attachment bolts is not recommended.
6. Measure engine crankshaft end play after assembly of torque converter. This value must be within one thousandth (.001) of an inch [0,0254mm] of end play recorded (in Paragraph #2) before assembly of torque converter.

802544 — 1.5 INCH [38,1] 32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	243970	Ring Gear Screw 1.5 Inch [38,1]
1	802550	Installation Instruction Sheet

802547 — 2.5 INCH [63,5] 32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	237153	Ring Gear Screw 2.5 Inch [63,5]
1	802550	Installation Instruction Sheet

802545 — 1.75 INCH [44,4] 32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	244903	Ring Gear Screw 1.75 Inch [44,4]
1	802550	Installation Instruction Sheet

802548 — 3.0 INCH [76,2] 32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	236938	Ring Gear Screw 3.0 Inch [76,2]
1	802550	Installation Instruction Sheet

802546 — 2.0 INCH [50,8] 32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	240318	Ring Gear Screw 2.0 Inch [50,8]
1	802550	Installation Instruction Sheet

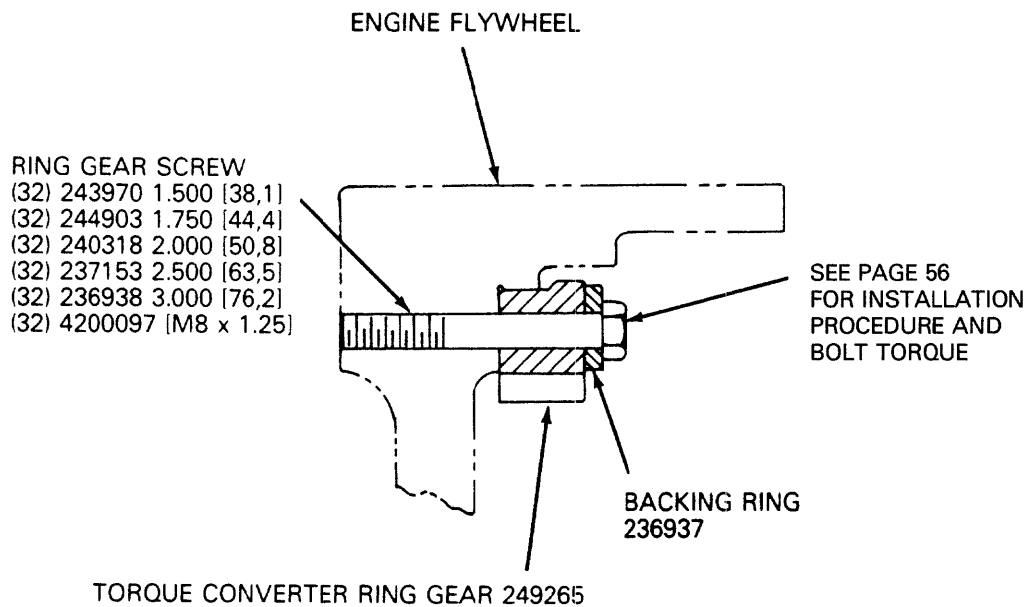
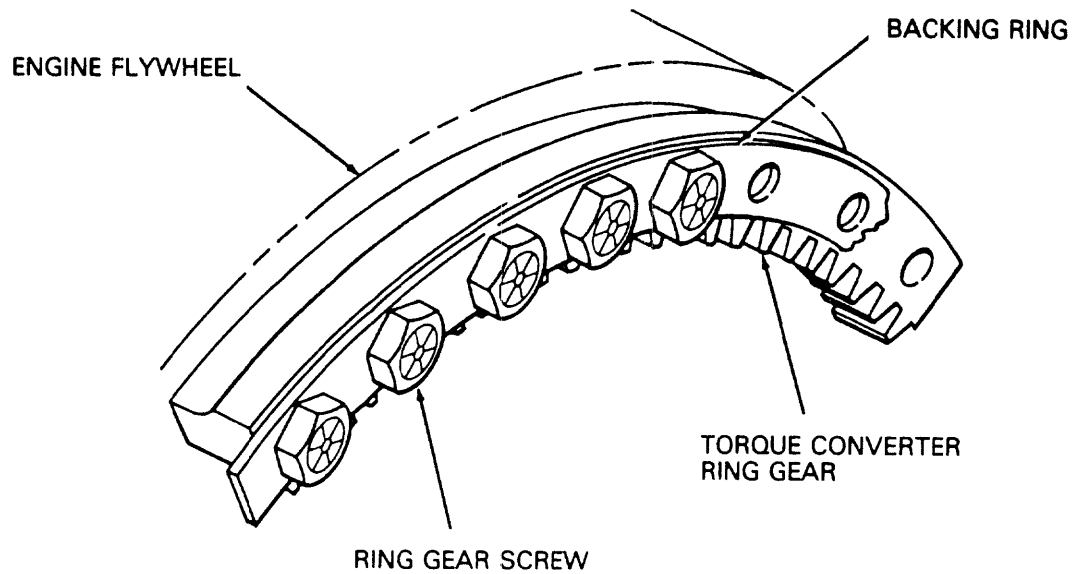
802549 — M8-32 SCREW RING GEAR KIT

1	249265	Torque Converter Ring Gear
32	4200097	Ring Gear Screw [M8 x 1.25]
1	802550	Installation Instruction Sheet

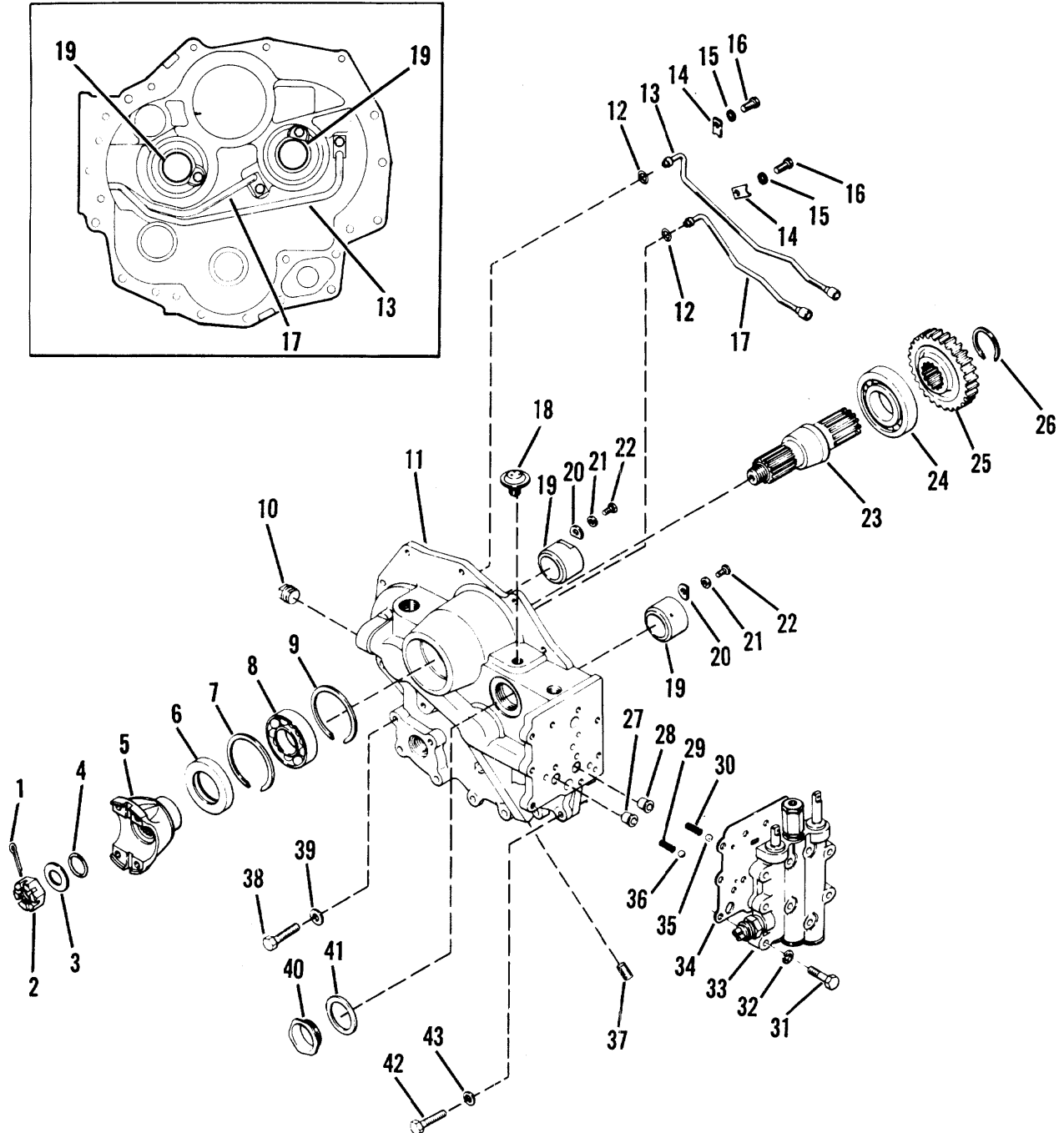
236937 Backing Ring Not Included in Ring Gear Kit. Must be Ordered Separately.

NOTE: The initial installation drive gear mounting kit includes a converter air breather. This breather is used on C & CL 270/C & CL 320 converters only and is not required for the HR & LHR 28000/HR & LHR 32000 applications.

SEE PAGE 57 FOR INSTALLATION ILLUSTRATIONS



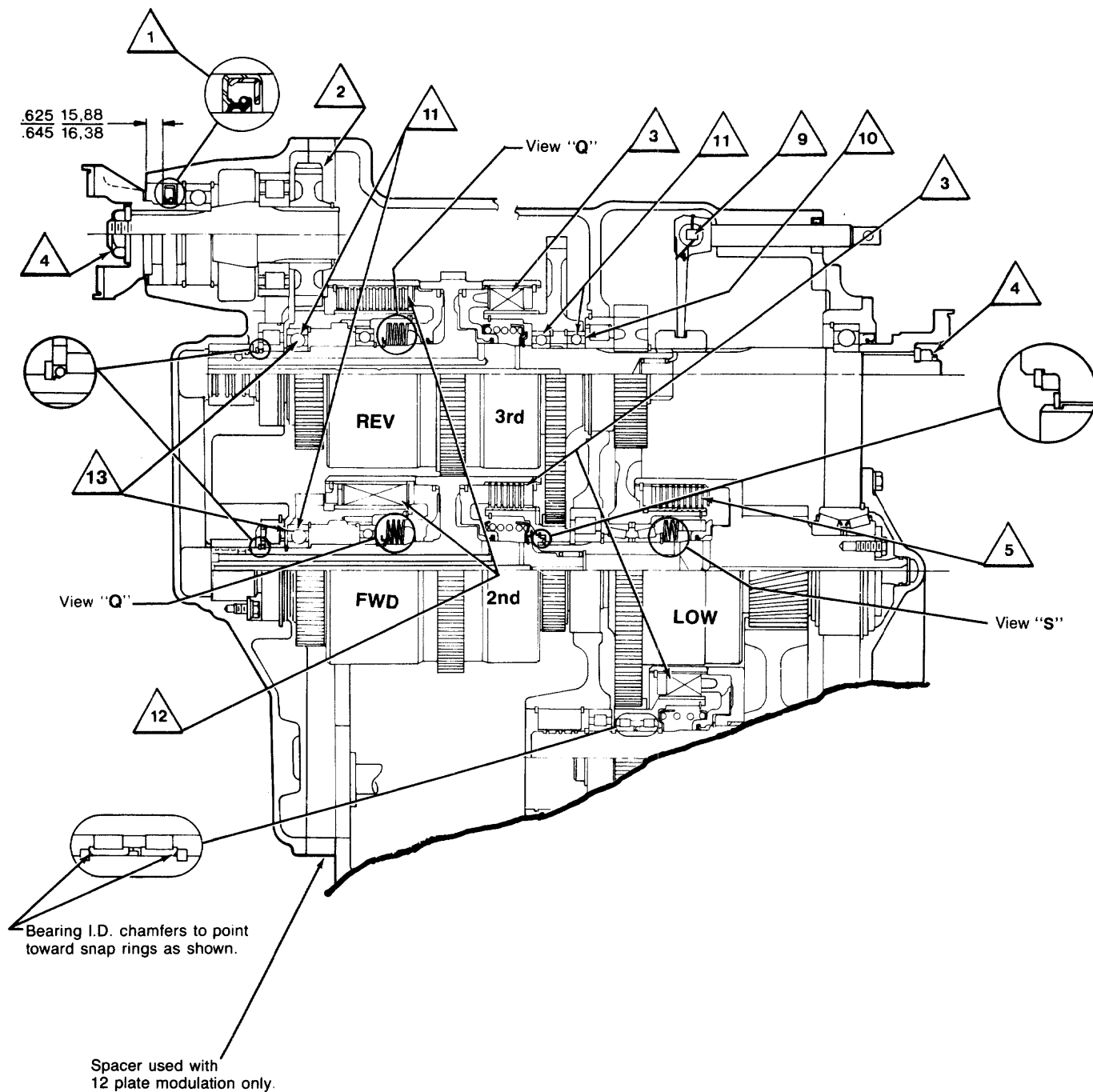
R-MODEL SECTION



R32000 FRONT COVER GROUP

ITEM	DESCRIPTION	QTY	ITEM	DESCRIPTION	QTY
1	Flange Nut Cotter	1	23	Input Shaft	1
2	Flange Nut	1	24	Input Shaft Rear Bearing	1
3	Flange Nut Washer	1	25	Input Shaft Gear	1
4	Flange "O" Ring	1	26	Input Shaft Gear Retaining Ring	1
5	Input Flange	1	27	Tube Sleeve	1
6	Input Flange Oil Seal	1	28	Tube Sleeve	1
7	Input Shaft Front Bearing Retaining Ring	1	29	Detent Spring	1
8	Input Shaft Front Bearing	1	30	Detent Spring	1
9	Input Shaft Front Bearing Retaining Ring	1	31	Valve to Converter Housing Screw	9
10	Pipe Plug	1	32	Valve to Converter Housing Screw Lockwasher	9
11	Front Cover & Tube Assembly	1	33	Control Valve Assembly	1
12	"O" Ring	2	34	Control Valve Gasket	1
13	3rd Speed Tube Assembly	1	35	Detent Ball	1
14	Tube Clip	2	36	Detent Ball	1
15	Tube Clip Screw Lockwasher	2	37	Pipe Plug	1
16	Tube Clip Screw	2	38	Cover to Case Screw	4
17	Reverse Tube Assembly	1	39	Cover to Case Screw Lockwasher	4
18	Breather	1	40	Front Cover Plug	1
19	Front Cover Sleeve	2	41	Front Cover Plug Gasket	1
20	Front Cover Sleeve Lock	2	42	Cover to Case Screw	4
21	Sleeve Lockscrew Lockwasher	2	43	Cover to Case Screw Lockwasher	4
22	Sleeve Lockscrew	2			

**R-32000
ASSEMBLY INSTRUCTION ILLUSTRATION**



- 1 Apply very light coat of Permatex No. 2 to O.D. of all oil seals before ass'y.
- 2 Gear to be assembled with long hub length to this side.
- 3 Three clutches, 6-outer steel plates, 6-inner friction plates. Assemble alternately, starting with outer steel plate.
- 4 See Elastic Stop Nut Torque Chart
- 5 Low clutch, 9-outer steel plates, 9-inner friction plates. Assemble alternately, starting with outer steel plate.

- 9 Lockwire to prevent loosening
- 10 Bearing shield out
- 11 Must be loose internal fit bearings, No. "3" etched on bearing.
- 12 (12 Plate Modulation) Two clutches, 12-outer steel plates, 12-inner friction plates. Assemble alternately, starting with outer steel plate.
- 13 Bearing shield in.

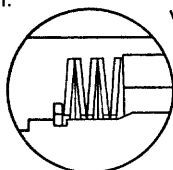
Notes

- A. - Use Permatex & Crane Sealer only where specified.
- B. - All lead in chamfers for oil seals, piston rings & "O" rings must be smooth & free from burrs. Inspect at ass'y.
- C. - Lubricate all piston ring grooves & "O" rings with oil before ass'y.
- D. - Apply very light coat of Permatex No. 2 to O.D. of all oil seals before ass'y.
- E. - After assembly of parts using Permatex or Crane sealer, there must not be any free or excess material that could enter the oil circuit.
- F. - Apply light coat of Crane Sealer to all pipe plugs.
- G. - Apply a thin coating of grease between seal lips on lip type seals prior to ass'y.
- H. - Apply light coat of Permatex No. 2 to all thru hole stud threads.

NOTE: Metric dimensions shown in brackets [].

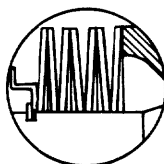
Low Clutch Return Springs.

Concave side of first belleville washer to be placed against clutch piston. Remaining four washers to be stacked alternately reversed as shown.



View "S"

View "Q"
2 Places



Forward & Reverse Clutch Return Springs.
Concave side of first belleville washer to be placed against clutch piston. Remaining six washers of each clutch to be stacked alternately reversed as shown.

ELASTIC STOP NUT TORQUE

THREAD SIZE	LB.-FT.	[N·m]
1" - 20	150 - 200	[203,4 - 271,1]
1 1/4" - 18	200 - 250	[271,2 - 338,9]
1 1/2" - 18	300 - 350	[406,8 - 474,5]
1 3/4" - 12	400 - 450	[542,4 - 610,1]

Grade 5

Torque Specification for Lubricated
or Plated Screw Threads

Grade 8

NOM. SIZE	FINE THREAD		COARSE THREAD		FINE THREAD		COARSE THREAD	
	LB-FT	[N·M]	LB-FT	[N·M]	LB-FT	[N·M]	LB-FT	[N·M]
.5625	91 - 100	[123,4 - 135,5]	82 - 90	[111,2 - 122,0]	128 - 141	[173,6 - 191,1]	115 - 127	[156,0 - 172,2]
.5000	64 - 70	[86,8 - 94,9]	57 - 63	[77,3 - 85,4]	90 - 99	[122,1 - 134,2]	80 - 88	[108,5 - 119,3]
.4375	41 - 45	[55,6 - 61,0]	37 - 41	[50,2 - 55,5]	58 - 64	[78,7 - 86,7]	52 - 57	[70,6 - 77,2]
.3750	26 - 29	[35,3 - 39,3]	23 - 25	[31,2 - 33,8]	37 - 41	[50,2 - 55,5]	33 - 36	[44,8 - 48,8]
.3125	16 - 20	[21,7 - 27,1]	12 - 16	[16,3 - 21,6]	28 - 32	[38,0 - 43,3]	26 - 30	[35,3 - 40,6]
.2500	9 - 11	[12,3 - 14,9]	8 - 10	[10,9 - 13,5]	11 - 13	[15,0 - 17,6]	9 - 11	[12,3 - 14,9]

MAINTENANCE AND SERVICE

The instructions contained herein cover the disassembly and reassembly of the transmission in a sequence that would normally be followed after the unit has been removed from the machine and is to be completely overhauled. It must also be understood that this is a basic 32000 transmission with many options. Companion flanges and output shafts with and without disconnect

assemblies may vary on specific models. The units are very similar to trouble shoot, disassemble, repair and reassemble.

CAUTION: Cleanliness is of extreme importance and an absolute must in the repair and overhaul of this unit. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

DISASSEMBLY

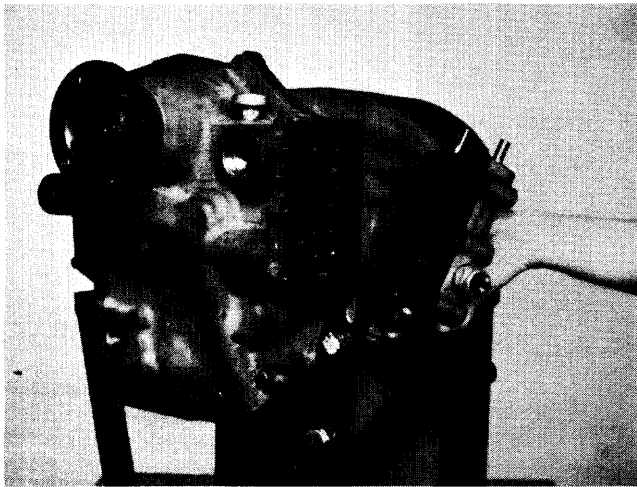


Figure 1

Remove control valve bolts and washers. Remove control valve. Use caution as not to lose detent springs and balls.

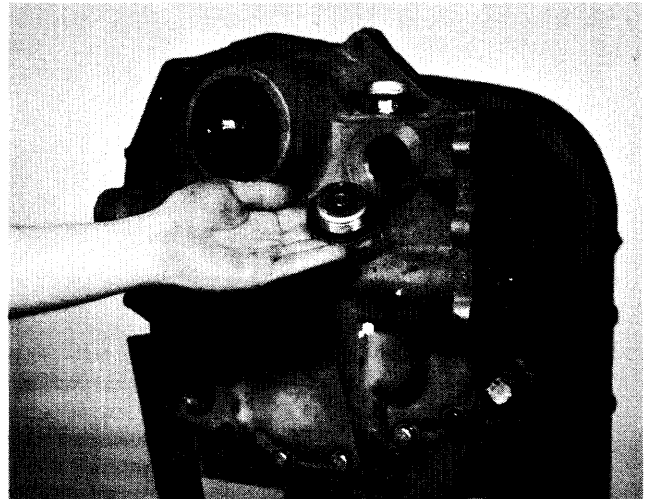


Figure 3

Remove front cover plug.

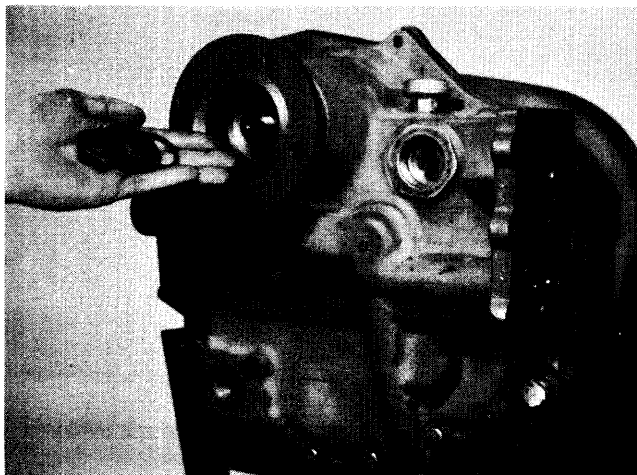


Figure 2

Remove companion flange nut, washer and "O" ring.

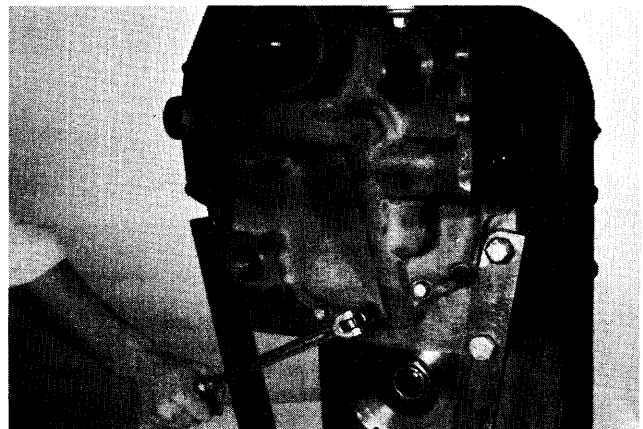


Figure 4

Remove bolts securing front cover to transmission housing.

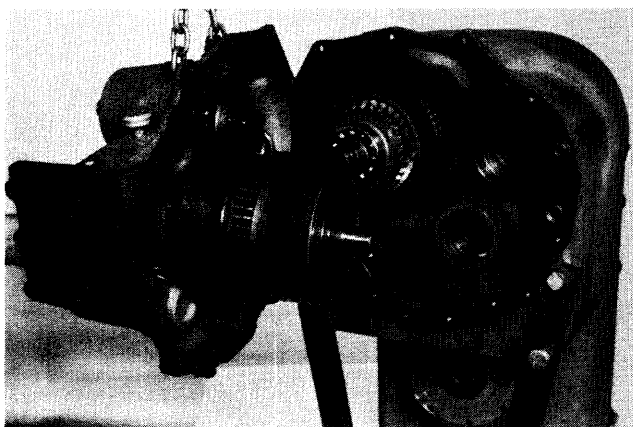


Figure 5

Remove front cover and forward and 2nd clutch.

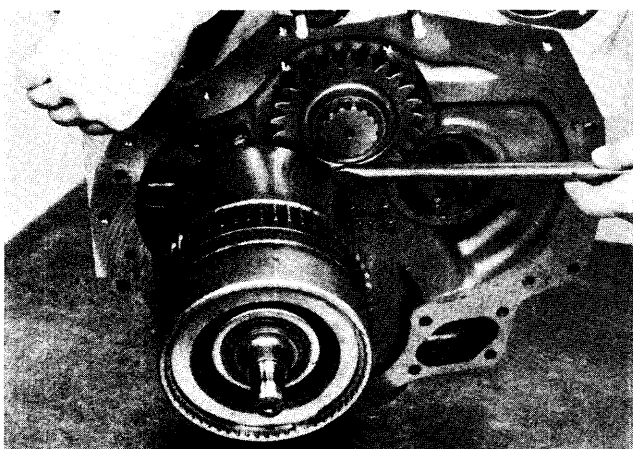


Figure 6

Use a spreading type snap ring pliers to spread the ears on forward clutch front bearing retainer ring. Remove forward clutch with pry bar.

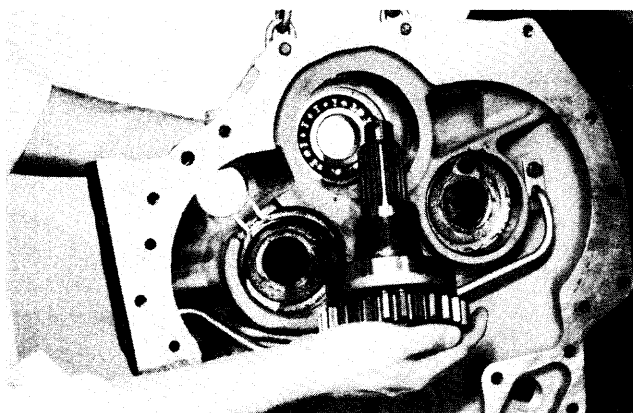


Figure 7

If input shaft is to be removed, tap on threaded end of shaft, remove input shaft, gear and bearing.

See cleaning and inspection page.

INSTALL INPUT SHAFT OIL SEAL IN FRONT COVER AS SHOWN ON PAGE 60.

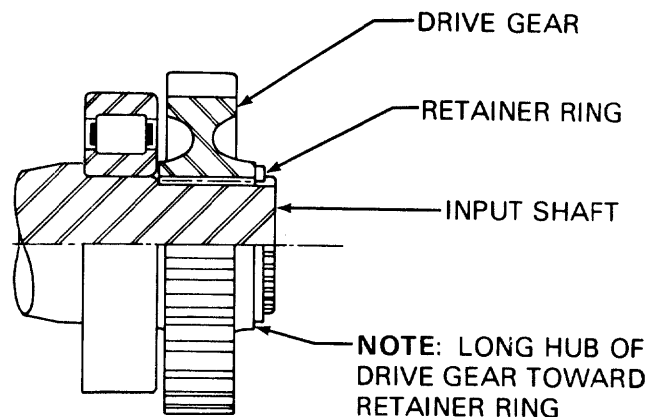


Figure 8

Input shaft, rear bearing, drive gear and snap ring.

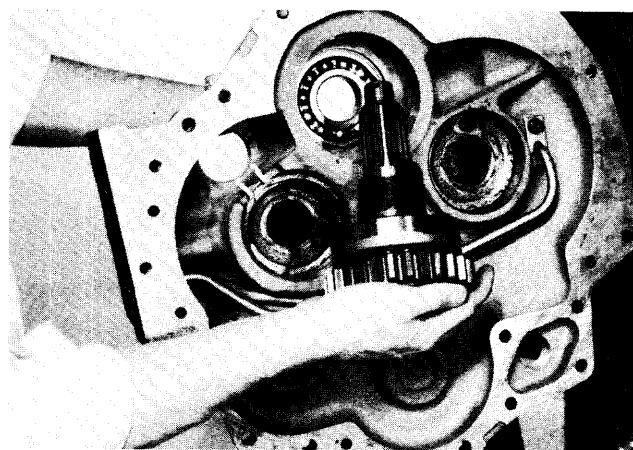


Figure 9

Install input shaft into front bearing.

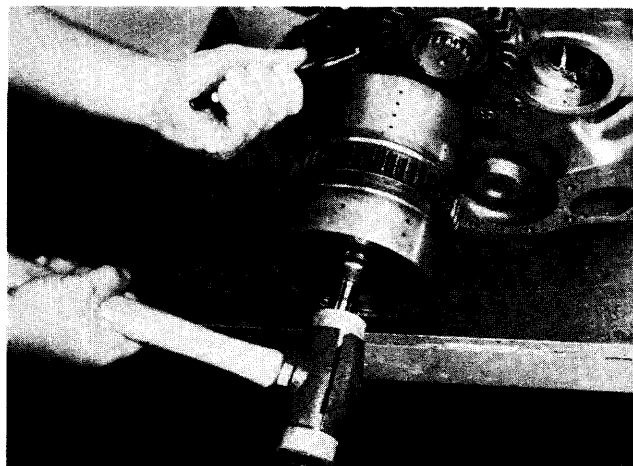


Figure 10

Support converter housing with chain fall. Spread forward clutch front bearing retainer ring and tap forward and 2nd clutch assembly into transmission case assembly. Be certain snap ring is in full position in ring groove.

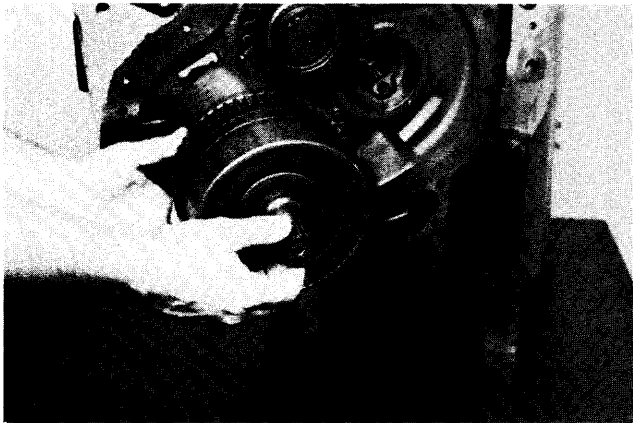


Figure 11
Install 2nd speed clutch pilot bearing.

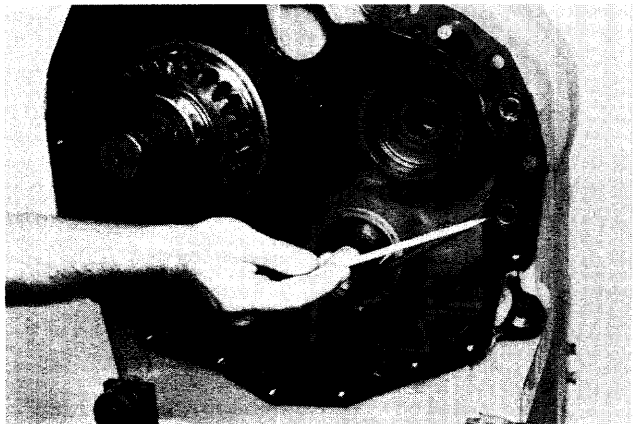


Figure 12
Install transmission case gasket and "O" ring seals.

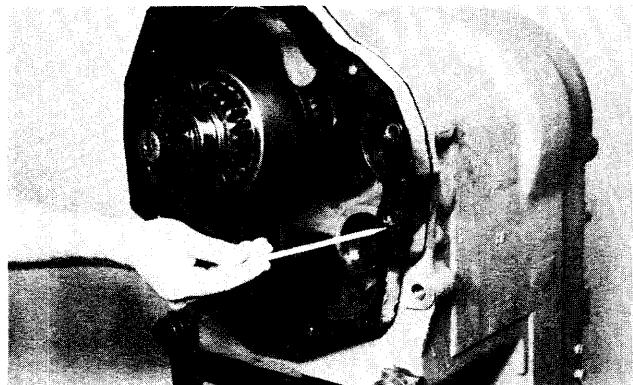


Figure 13
Install housing spacer, gasket and "O" ring seals. **NOTE:** Housing spacer is used with 12 plate clutch modulation only.

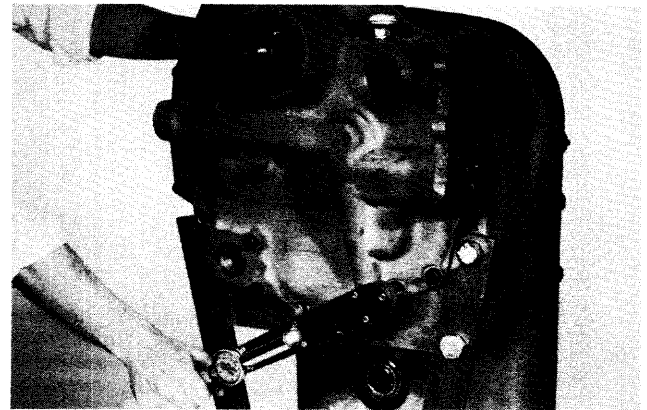


Figure 14
Support front cover with a chain fall. Install alignment studs in transmission case. Position front cover assembly on aligning studs. Turn output flange to align clutch disc hub in clutch. Do not force this operation. With front cover in position against the transmission case install cover to case bolts. Tighten to specified torque.

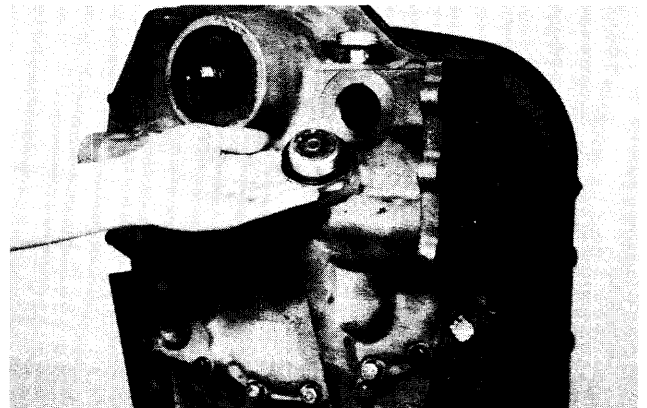


Figure 15
Install front cover plug.

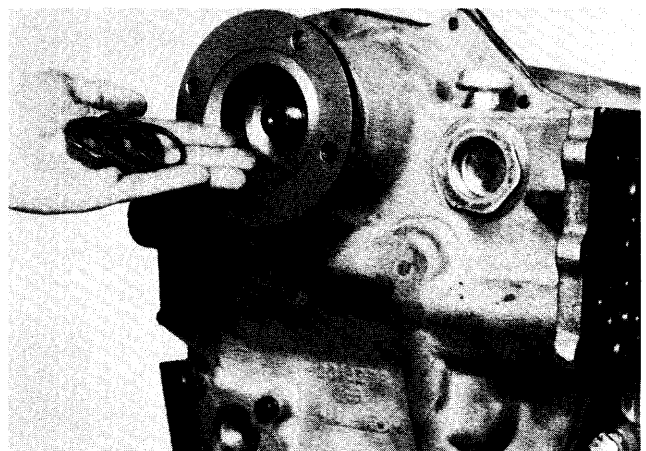


Figure 16
Install companion flange, flange "O" ring, washer and nut. Torque nut to specified torque. (See elastic stop nut torque chart).

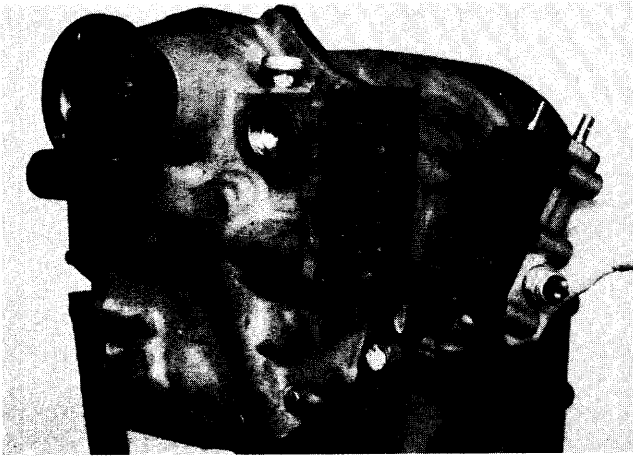
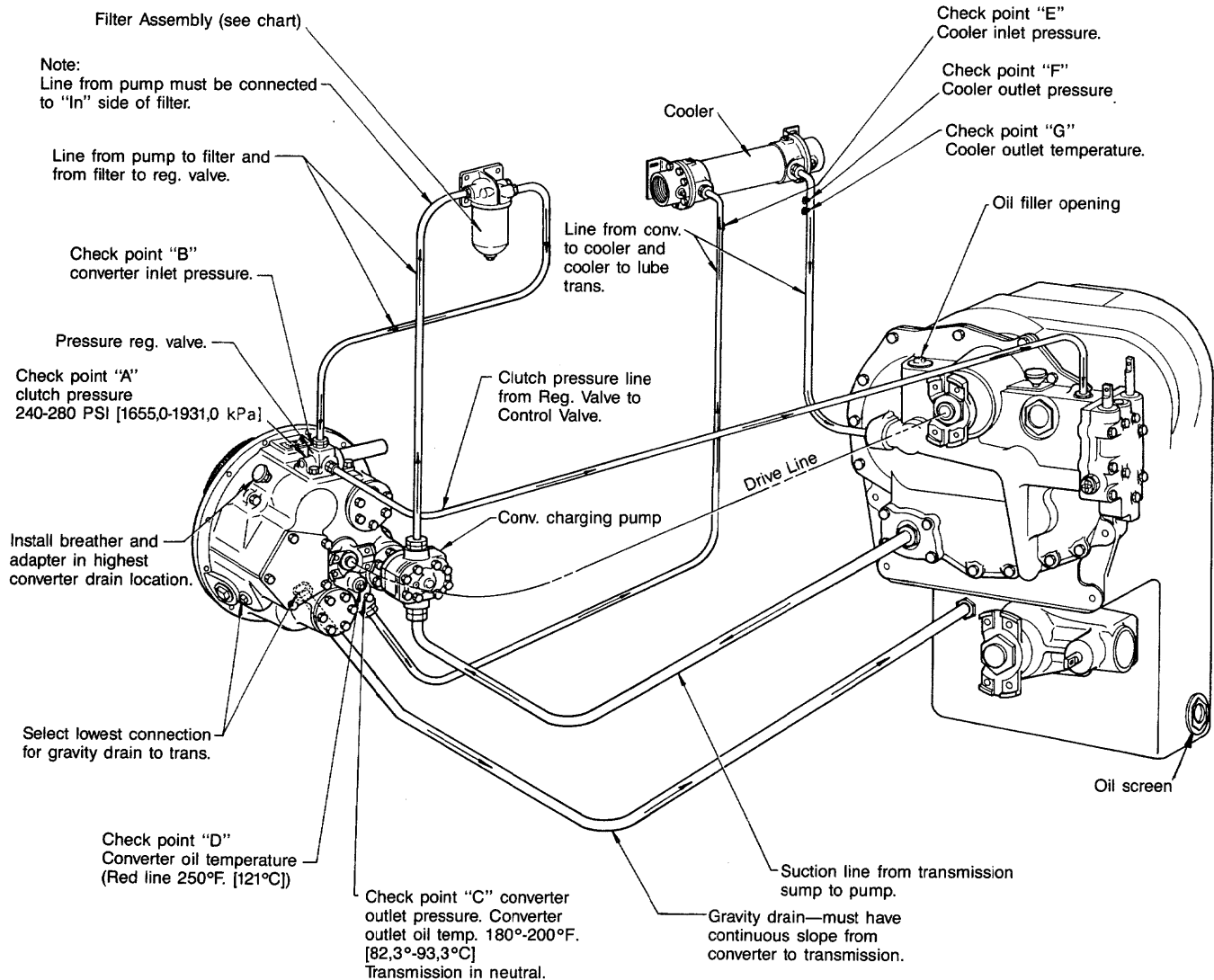


Figure 17

Locate detent balls and springs in control valve. Position new gasket. Secure valve with bolts and washers. Tighten to specified torque.

R32000 - C270/C320 EXTERNAL PLUMBING DIAGRAM



Metric dimensions shown in brackets [].

Note: Do not deviate any line size.

FILTER ASSEMBLY CHART

Filter Type	Assembly No.	Cartridge No.	Spin-on Type	
			Assembly No.	Element
A	1533614 Single Can	215502	247055 Single Element	247052
B	234777 Dual Can	215502	246787 Dual Element	243622

Notes:

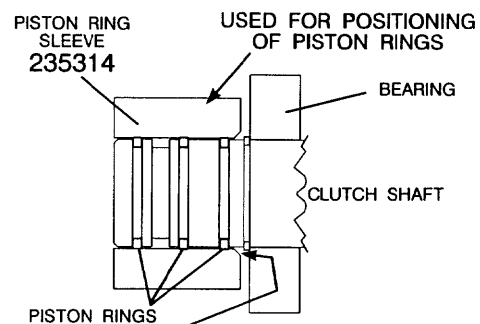
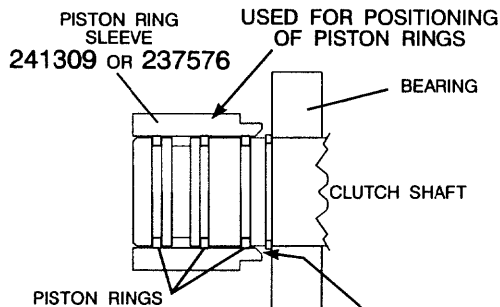
Hose line operating requirements.

- Pressure Lines**—Suitable for operation from ambient to 250°F. [121,1°C] continuous operating temperature. Must withstand 300 PSI [2068 kPa] continuous pressure with 600 PSI [4137 kPa] intermittent surges. Ref. S.A.E. Spec. No. J517,100R1 Hydraulic Hose Specification.
- Suction Line**—To be protected from collapse by interwoven steel wire. Ref. S.A.E. Spec. No. J517,100R4 Hydraulic Hose Specification. Suitable for operation from ambient to 250°F. [121,1°C]. Continuous operating temperature.
- Gravity Drain Line**—Suitable for operation from ambient to 250°F. [121,1°C] continuous operating temperature. Ref. S.A.E. Spec. No. J517,100R1 Hydraulic Hose Specification.
- All Hose Lines** used must conform to S.A.E. Spec. No. J1019 Test Procedure for High Temp. Transmission Oil Hose.
- See Lubrication Specifications.

PROPER INSTALLATION OF TEFLON PISTON RING AND PISTON RING EXPANDER SPRINGS

NOTE: NOT ALL TRANSMISSIONS WILL HAVE TEFLON PISTON RINGS AND EXPANDER SPRINGS

1. Fill the oil sealing ring grooves with a good grade of grease, this will help stabilize the teflon ring and expander spring in the ring groove for installation
2. Position the expander spring in the inner groove of the new piston ring, with the expander spring gap 180° from the hook joint gap of the piston ring.
3. Carefully position the piston ring and expander spring on the clutch shaft in the inner most ring groove. Hook the piston piston ring joint.
4. Repeat steps 1, 2 and 3 for the remaining ring or rings making certain all hook joints are fastened securely.
5. Apply a heavy coat of grease to the outer diameter of the rings and clutch shaft. Center the piston ring's in the ring groove.
6. Before installing the clutch assembly in the transmission case it is recommended a piston ring sleeve P/N's 241309, 237576, or 235314 be used to center all of the piston rings in their respective ring grooves. Use extreme caution to not damage piston ring when installing the clutch shaft in the transmission case, or when installing the converter housing or front cover on the clutch shafts.



Be sure that lead in chamfer and intersection of lead in chamfer to piston ring bore is free of burrs and nicks.

28000, 32000 SERIES

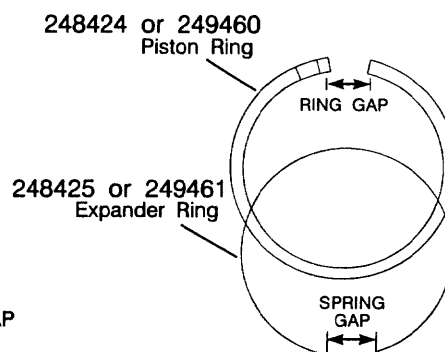
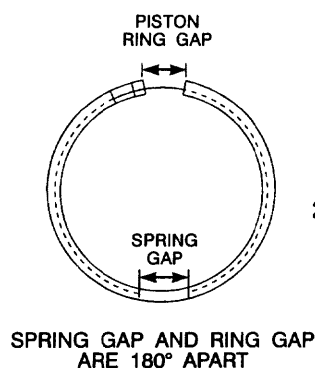
248424 - Piston Ring

248425 - Expander Spring

28000, 32000 SERIES 4TH CLUTCH SHAFT

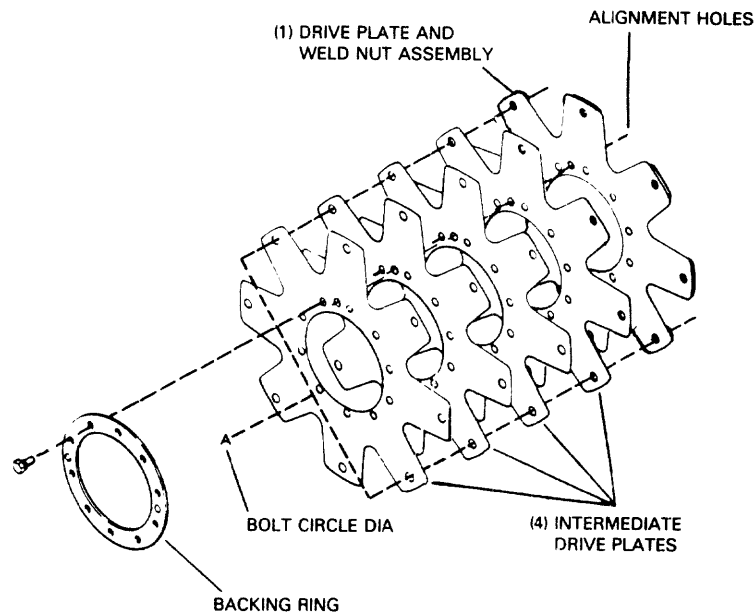
249460 - Piston Ring

249461 - Expander Spring



32000 DRIVE PLATE INSTALLATION

Measure the "A" dimension (Bolt Circle diameter) and order Drive Plate Kit listed below.



"A" Dimension (Bolt Circle Diameter)

13.125" [333,375 mm] Diameter

Kit No. 802335

13.50" [342,900 mm] Diameter

Kit No. 802333

17.00" [431,800 mm] Diameter

Kit No. 802454

Each kit will include the following parts:

- 4 Intermediate Drive Plates
- 1 Drive Plate and Weld Nut Assembly.
- 1 Backing Ring.
- 10 Screw and Lockwasher Assembly.
- 1 Instruction Sheet.

TO FACILITATE ASSEMBLY, ALIGN SMALL HOLES IN DRIVE PLATES — SEE ILLUSTRATION ABOVE.

Position drive plate and weld nut assembly on impeller cover with weld nuts toward cover. Align intermediate drive plate and backing ring with holes in impeller cover. **NOTE:** Two dimples 180° apart in backing ring must be out (toward engine flywheel). Install capscrews and washers. Tighten 23 to 25 ft. lbs. torque [31,2 - 33,8 N.m].

**SEE PAGE 69 FOR TRANSMISSION TO ENGINE
INSTALLATION PROCEDURE**

TRANSMISSION TO ENGINE INSTALLATION PROCEDURE

1. Remove all burrs from flywheel mounting face and nose pilot bore. Clean drive plate surface with solvent.
2. Check engine flywheel and housing for conformance to standard S.A.E. #3 - S.A.E. J-927 tolerance specifications for pilot bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
3. Install two 3.50 [88,90 mm] long transmission to flywheel housing guide studs in the engine flywheel housing as shown. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing access hole.
4. Install a 4.00 [101,60 mm] long drive plate locating stud .3750-24 fine thread in a drive plate nut. Align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step No. 3.
5. Locate transmission on flywheel housing aligning drive plate to flywheel and transmission to flywheel housing.

Install transmission to flywheel housing screws. Tighten screws to specified torque. Remove transmission to engine guide studs. Install remaining screws and tighten to specified torque.

6. Remove drive plate locating stud.
7. Install drive plate attaching screw and washer. Snug screw but **do not tighten**. Some engine flywheel housings have a hole located on the flywheel housing circumference in line with the drive plate screw access hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate screws. Rotate the engine flywheel and install the remaining seven (7) flywheel to drive plate attaching screws. Snug screws but do not tighten. After all eight (8) screws are installed torque each one 25 to 30 ft. lbs. torque [33,9 - 40,6 N.m.]. This will require torquing each screw and rotating the engine flywheel until the full amount of eight (8) screws have been tightened.
8. Measure engine crankshaft end play after transmission has been completely installed on engine flywheel. This value must be within .001 [0,025 mm] of the end play recorded in step No. 2.

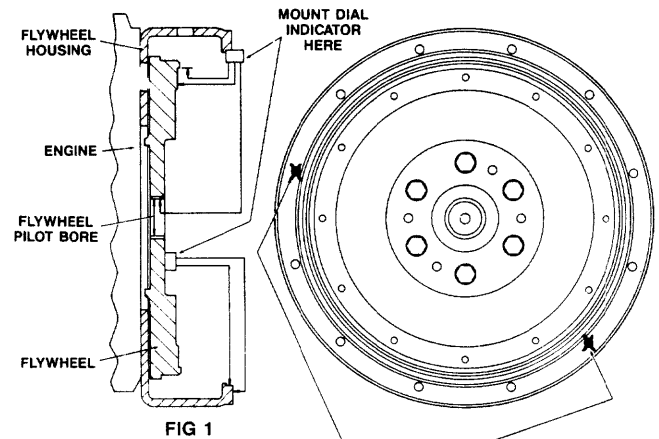


FIG 1

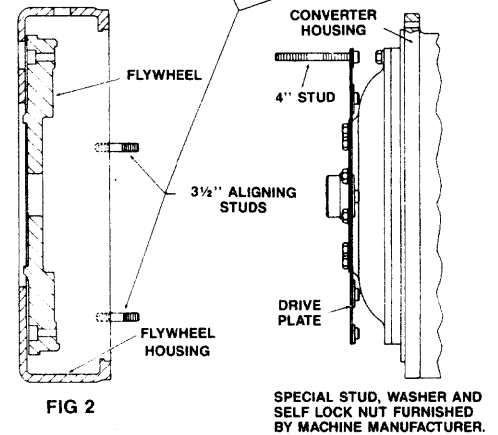


FIG 2

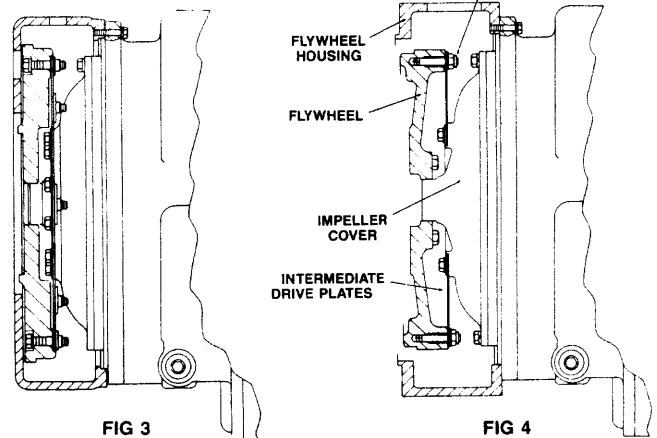


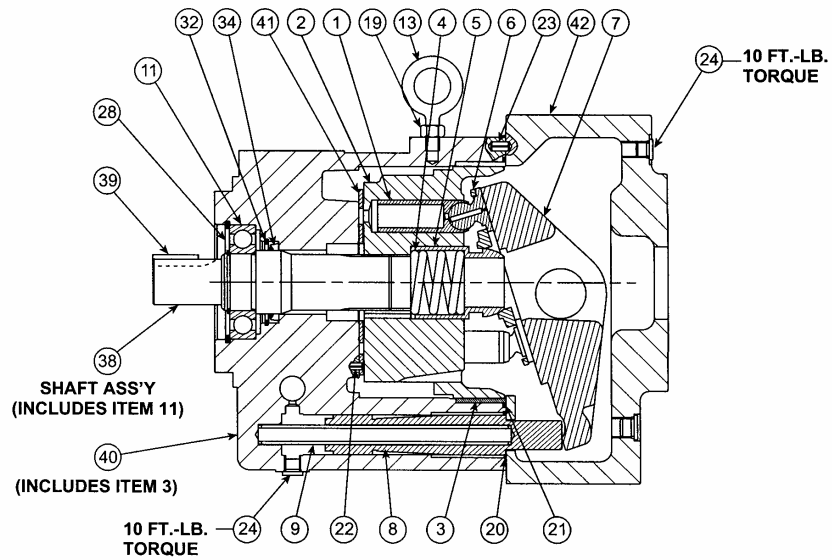
FIG 3

FIG 4

F-Series Hydraulic Systems

Service Parts Guide

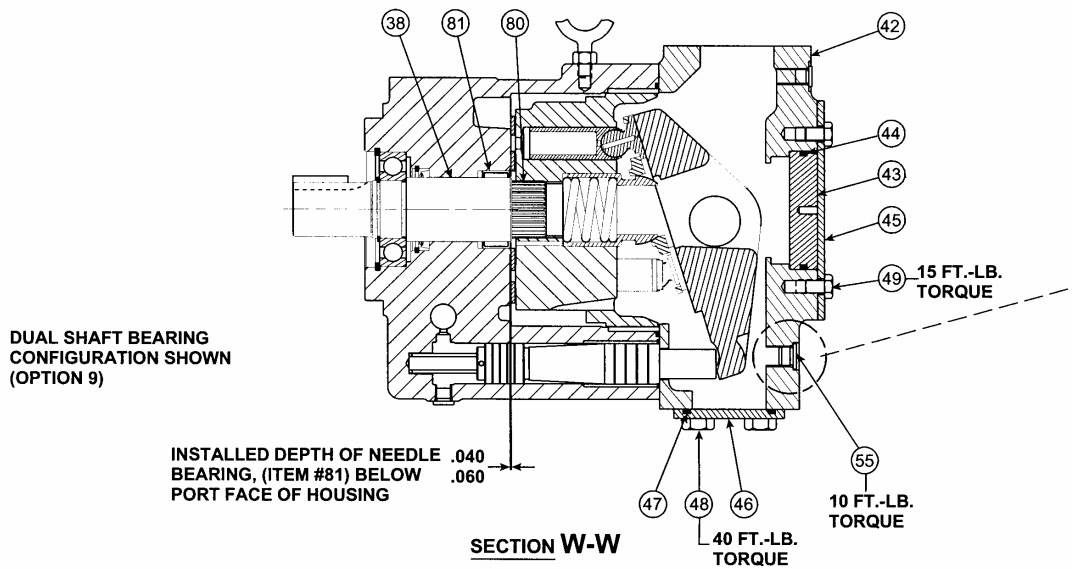
PAVC SERIES VARIABLE VOLUME PISTON PUMP



SECTION W-W

NOTE:

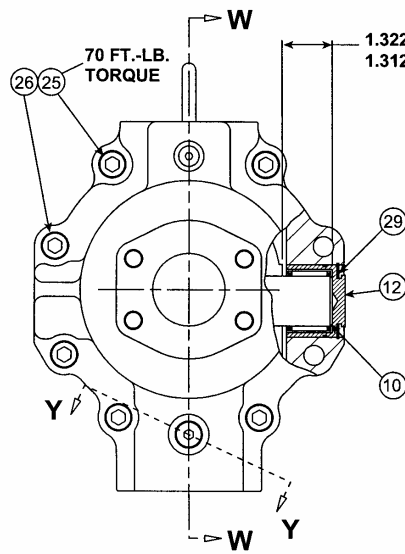
1. PUMP SHOWN WITH INLET PORT OPTION "OMIT" (REAR PORT)



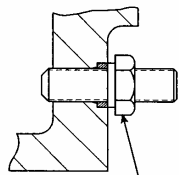
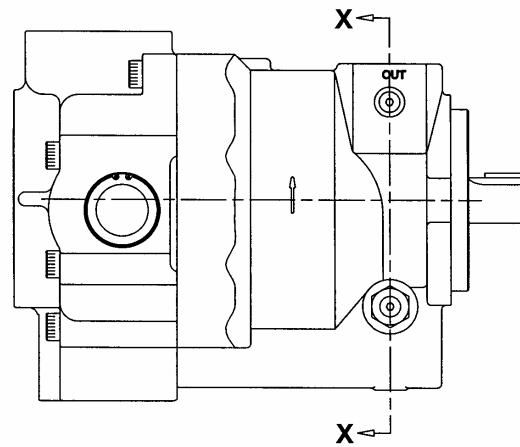
SECTION W-W

NOTE:

1. PUMP SHOWN WITH INLET PORT OPTION "2" (TOP/BOTTOM PORTS).



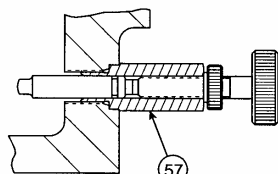
1.322 INSTALLED HEIGHT OF TRUNNION PIN (ITEM #10)
1.312 INTO SWASHPLATE (ITEM #7) (INTERFERENCE FIT)



56

25-30 FT.-LB. TORQUE

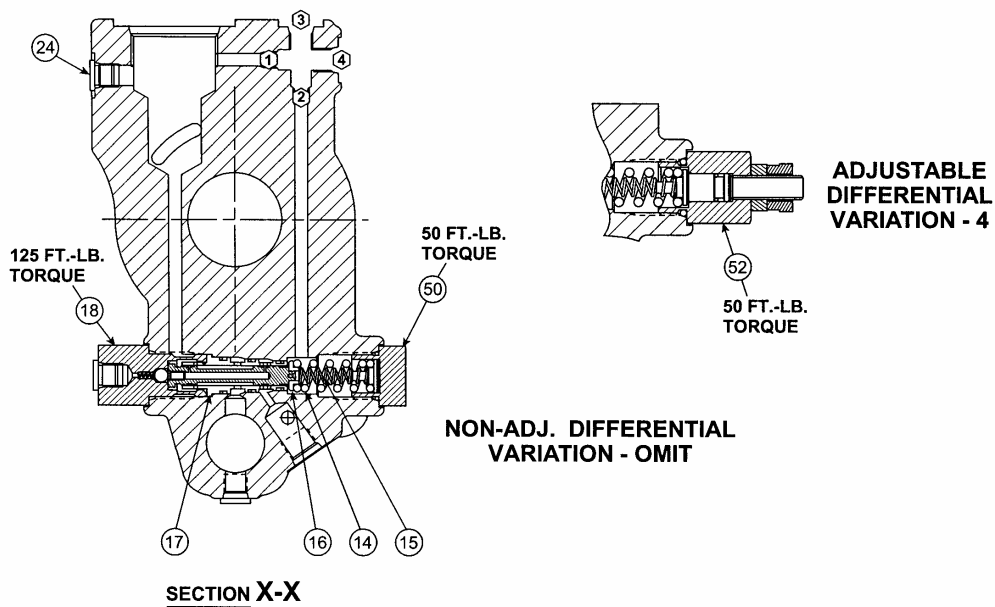
**MAXIMUM VOLUME STOP
VARIATION - 2**



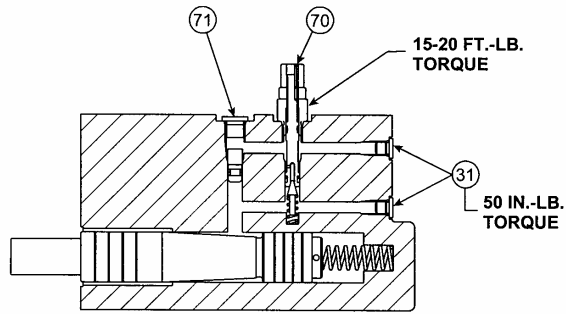
57

17 FT.-LB. TORQUE

**MAXIMUM VOLUME STOP
VARIATION - 5**

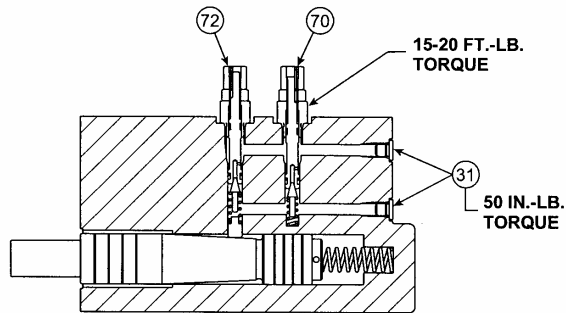


CONTROL OPTION	POSITION			
	1	2	3	4
OMIT	OPEN	690870	108X4	108X4
A	102X1	690870	OPEN	108X4
C	102X1	690870	OPEN	108X4
H	OPEN	690870	108X4	108X4
M	690870	OPEN	OPEN	108X4
ME	102X1	690870	OPEN	108X4
S	690870	OPEN	OPEN	108X4
SE	102X1	690870	OPEN	108X4
AM	102X1	690870	786635	OPEN
CM	102X1	690870	786635	OPEN
HM	690870	OPEN	OPEN	108X4



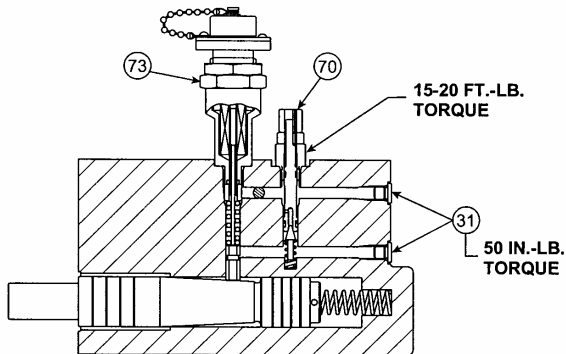
SECTION Y-Y

CONTROL OPTIONS
"OMIT", "M", "A" AND "AM"



SECTION Y-Y

CONTROL OPTIONS
"H", "C", "HM" AND "CM"



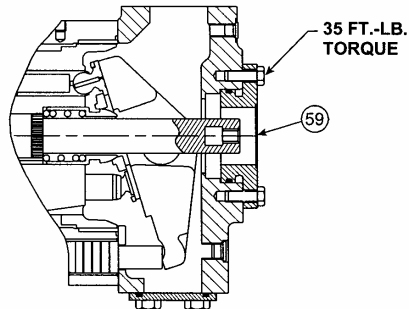
SECTION Y-Y

CONTROL OPTIONS
"S" AND "SE"

THRU-SHAFT PUMP OPTIONS

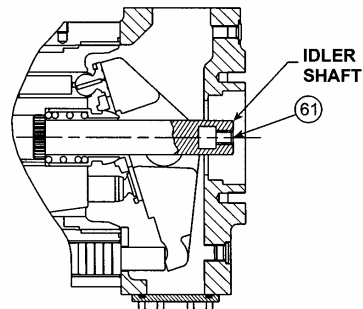
VARIATION "6A1"

PILOT DIAMETER: 2.000
SHAFT LENGTH: 1.00-1.50
SHAFT: .500 X .125 KEY



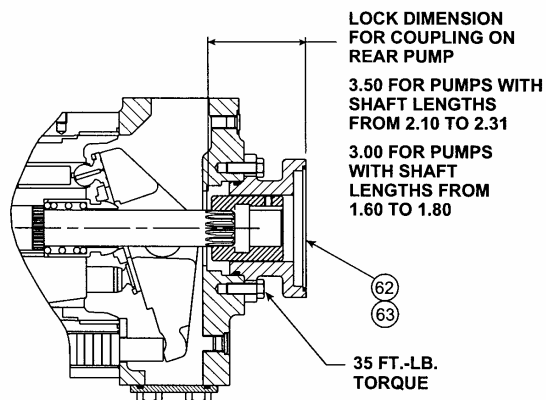
VARIATION "6A4"

PILOT DIAMETER: 3.250
SHAFT LENGTH: 1.25-1.40
SHAFT: 9 TOOTH 16/32 PITCH



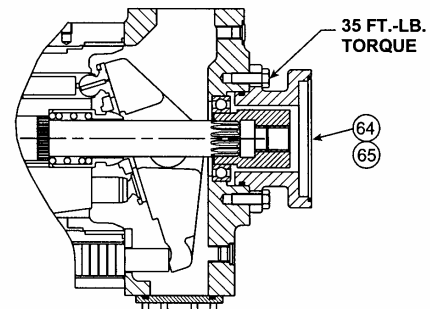
VARIATION "6B1" & "6B2"

PILOT DIAMETER: 4.000
SHAFT LENGTH: 1.62-2.31
SHAFT (6B1): .875 X .250 KEY
SHAFT (6B2): 1.000 X .250 KEY



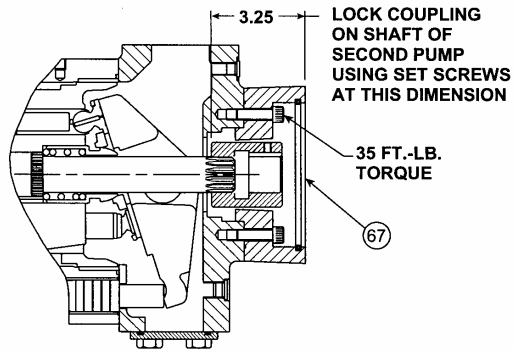
VARIATION "6B3" & "6B4"

PILOT DIAMETER: 4.000
SHAFT LENGTH: 1.62-2.31
SHAFT (6B3): 13 TOOTH 16/32 PITCH
SHAFT (6B4): 15 TOOTH 16/32 PITCH



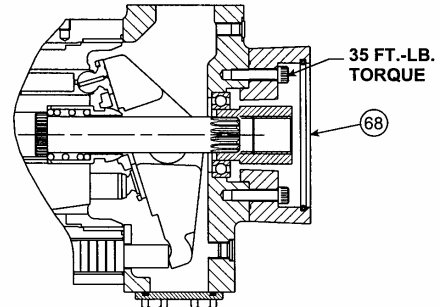
VARIATION "6C2"

PILOT DIAMETER: 5.000
SHAFT LENGTH: 1.80-2.20
SHAFT: 1.250 X .312 KEY



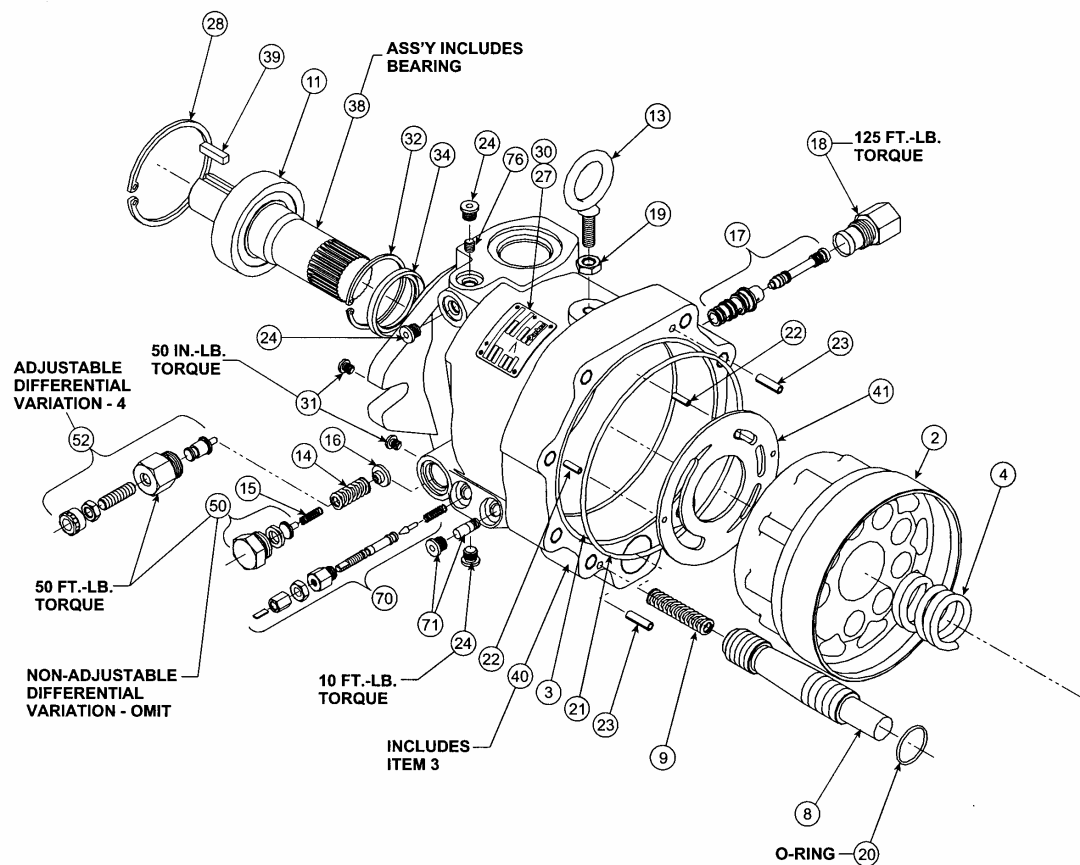
VARIATION "6C3"

PILOT DIAMETER: 5.000
SHAFT LENGTH: 1.80-2.20
SHAFT: 14 TOOTH 12/24 PITCH



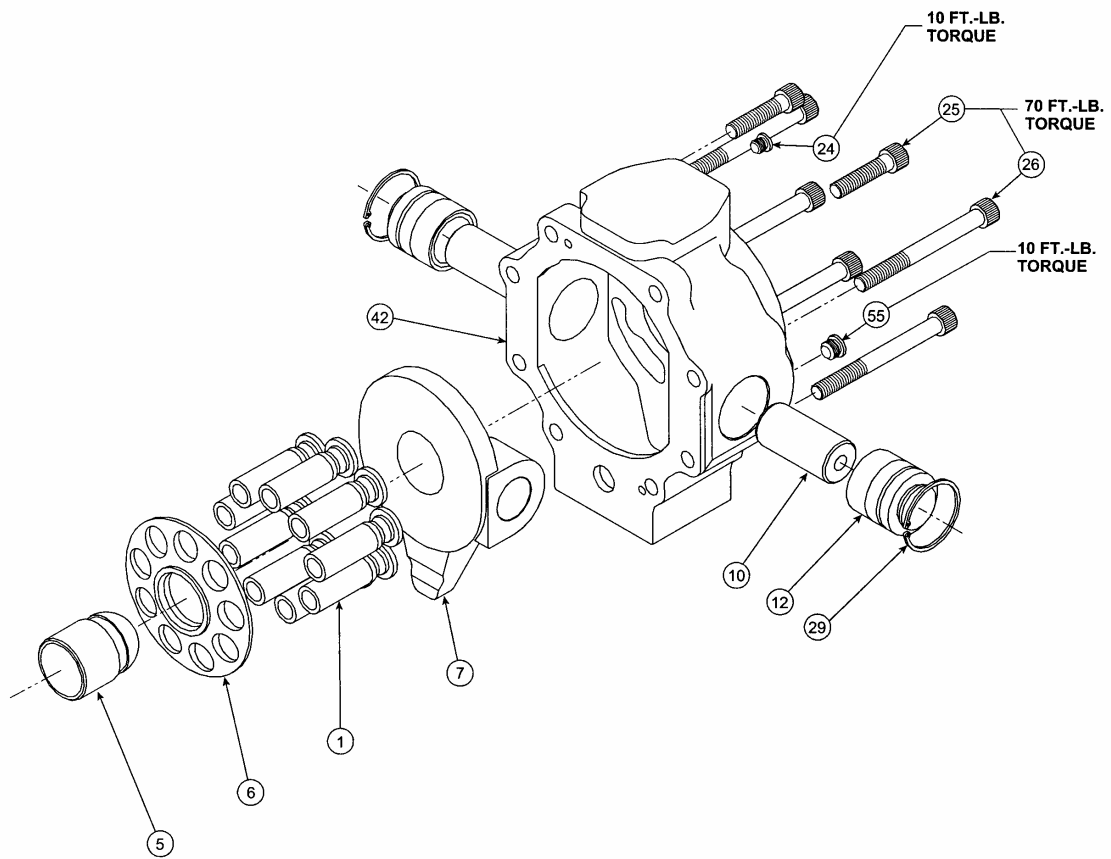
NOTE:

1. IDLER SHAFT INSTALLED THROUGH FRONT OF PUMP.
(REMOVE INPUT SHAFT, INSTALL IDLER, RE-INSTALL INPUT SHAFT.)



NOTES:

1. PUMP SHOWN IN CLOCKWISE ROTATION, CONTROL OPTION "OMIT", AND REAR INLET PORT. FOR COUNTERCLOCKWISE ROTATION OUTLET PORT, CONTROL DRAIN AND PUMP CONTROLS WILL BE ON OPPOSITE SIDE.

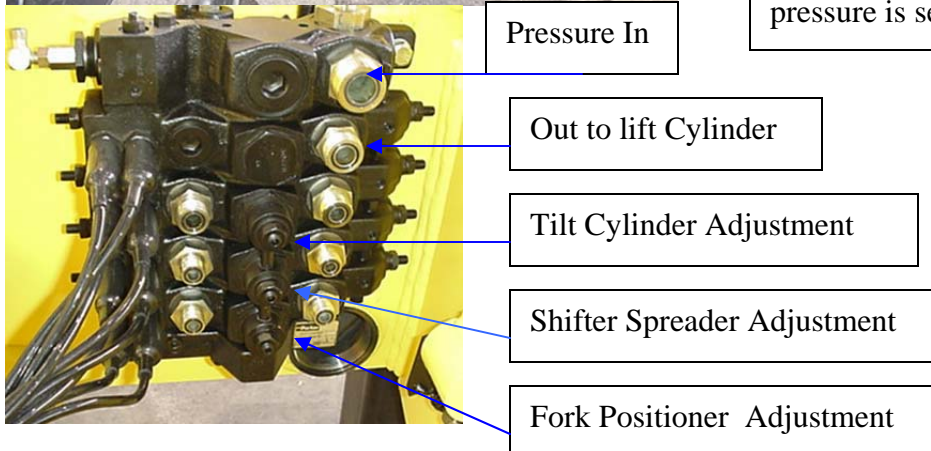
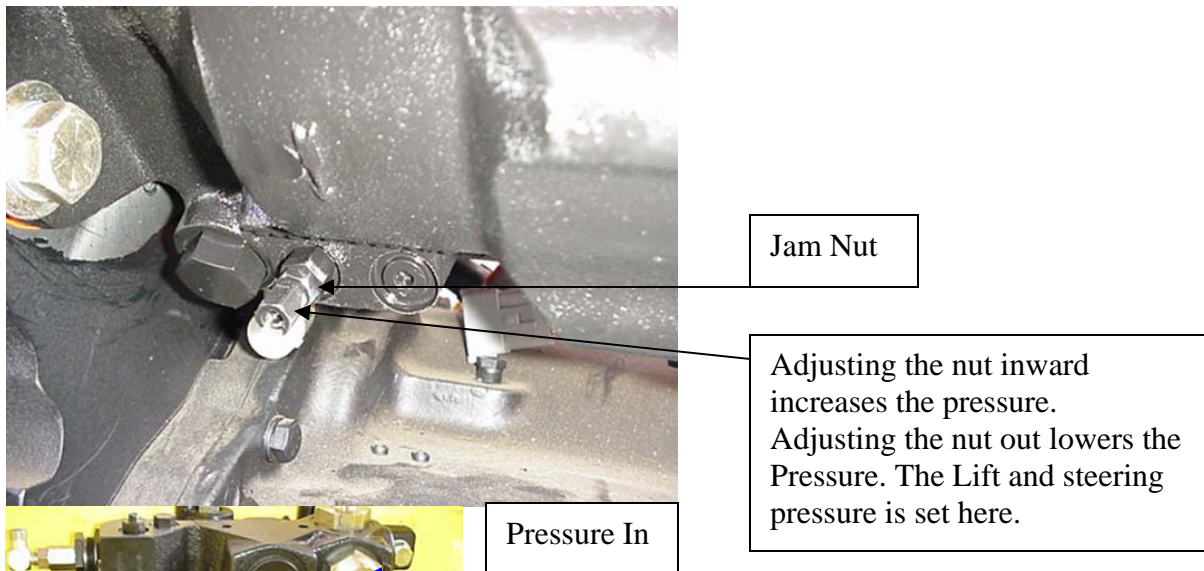
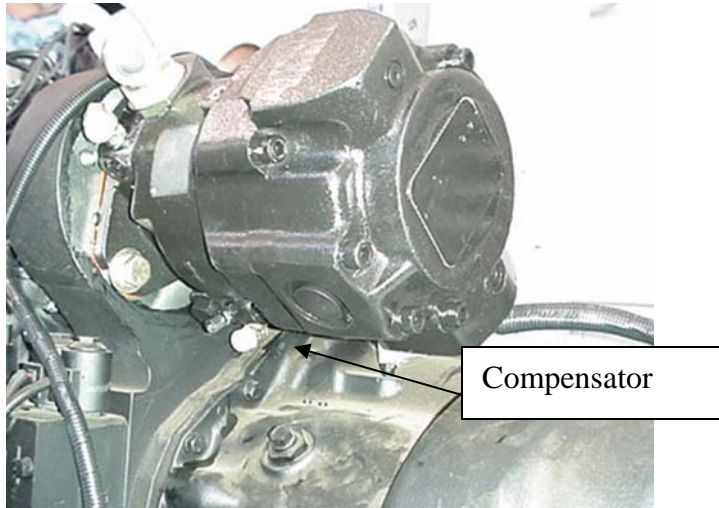


H01413 HYDRAULIC PUMP

ITEM	PART NUMBER	DESCRIPTION	QTY
1	H01687	PISTON ASSEMBLY	9
2	H01688	BARREL	1
3	H01689	BUSHING-BARREL	1
4	H01690	SPRING-BARREL	1
5	H01691	BALL SEAT	1
6	H01692	SLIPPER RETAINER	1
7	H01693	SWASH PLATE	1
8	H01694	PISTON	1
9	H01695	SPRING	1
10	H01696	TRUNNION PIN	2
11	H01697	BEARING-BALL	1
12	H01698	TRUN. CAP ASSEMBLY	1
13	H01699	EYE BOT	1
14	H01700	SRPING- MODULATOR	1
15	H01701	SPRING-UPSTROKE	1
16	H01702	RETAINER-SPRING	1
17	H01703	SPOOL&SLEEVE ASSY	1
18	H01704	AIRBLEED ASSY	1
19	H01705	JAM NUT	1
20	H01706	O-RING	1
21	H01707	O-RING	1
22	H01708	ROLL PIN	2
23	H01709	ROLL PIN	2
24	H01710	PLUG	3
25	H01711	CAP SCREW	2
26	H01712	CAP SCREW	6
27	H01713	NAME PLATE	1
28	H01714	SNAP RING	1
29	H01715	SNAP RING	2
30	H01716	DRIVE SCREW	2
31	H01717	PLUG	2
32	H01718	SNAP RING	1
34	H01719	SHAFT SEAL-VITON	1
38	H01720	SHAFT SPLINE ASSY	1
39	H01721	KEY	1
40	H01722	FRONT HOUSING ASSY	1
41	H01723	PORT PLATE	1
42	H01724	TRUNNION HOUSING	1
43	H01725	THRU-SHAFT PLUG	1
44	H01726	O-RING	1

ITEM	PART NUMBER	DESCRIPTION	QTY
45	H01727	COVER PLATE	1
46	H01728	INLET COVER	1
47	H01729	O-RING	1
49	H01730	BOLT	4
50	H01731	NON-ADJ DIFF ASSY	OMIT
52	H01732	ADJ DIFF ASSY	4
55	H01733	PLUG	OMIT
56	H01734	MAX VOL STOP-VAR 2	1
57	H01735	MAX VOL STOP -VAR5	1
59	H01736	ADAPTER KIT "AA"	1
61	H01737	ADAPTER KIT "A"	1
62	H01738	ADAPTER KIT "B"	1
63	H01739	ADAPTER KIT "BB"	1
64	H01740	ADAPTER KIT "B"	1
65	H01741	ADAPTER KIT "BB"	1
67	H01742	ADAPTER KIT "C"	1
68	H01743	ADAPTER KIT "C"	1
70	H01744	PRESS COMP ASSY	
71	H01745	TORQUE PLUG ASSY	
72	H01746	TORQUE CONTROL ASSY	
73	H01747	CONTROL ASSY	
74	H01748	PIPE PLUG	
76	H01749	ORIFICE PLUG	
77	H01750	ORIFICE FITTING	
80	H01751	IDLER SHAFT	1
81	H01752	NEEDLE BEARING	1

FKS Hydraulic Pressure Setting and Locations



Adjustment for FKS series

The system has a 100cc PAVC pump and a Pulsar valve to control the mast. This pump also provides pressure for the brakes and steering.

To set the system up make sure the oil level is to the full mark with the mast lowered.

1. Check oil level
2. Place a pressure gauge at the outlet of the pump (minimum 3000 PSI range)
3. Start the engine
4. Cycle the brake pedal until the charge valve cycles to fill the accumulator.
5. The pressure gauge should rise to 2400-PSI +/- 150 PSI and then drop to 500 PSI.
6. If the charge will not fill and cycle brake to standby of 500 PSI the max pressure of the pump needs to be adjusted or the brake valve is defective.
7. The main pump pressure needs to be 100 to 200 PSI above the 2400 PSI steer pressure to satisfy the priority. This can be checked in the same manner and gauge position by tilting full forward or back and checking gauge.
8. To set the pump loosen the jam nut on the compensator on the bottom side of the pump and adjust it inward (clockwise) to a pressure that the brake charge valve cycles but do not exceed 3000 PSI.
9. If the brake valve will not cycle at this setting the valve is defective.
10. After you have reset the pump cycle the brakes several times to make sure they are working correctly.
11. Check the function of the joysticks, if you have a problem start at the valve with a ½" wrench and activate the spools manually to determine if the problem is electrical or hydraulic.
12. If the functions work manually then start by looking at the control card at the Green and Yellow/Red LED lights. The Yellow LED indicates normal status. Red LED indicates error.
13. The green lights should come on when the joystick is pulled one way and the other green light should go on when the stick is moved in the opposite direction. If they don't you do not have input from the joystick.
14. If you do not have the green lights there should be a Red light that indicates output on the card, if you have Red light coming on the next step is to go to the connector at the valve.
15. Put a test light on the two-wire lead and move the joystick, the light should light.

Reference, IQAN-TOC2 Instruction for further adjustments and trouble-shooting.

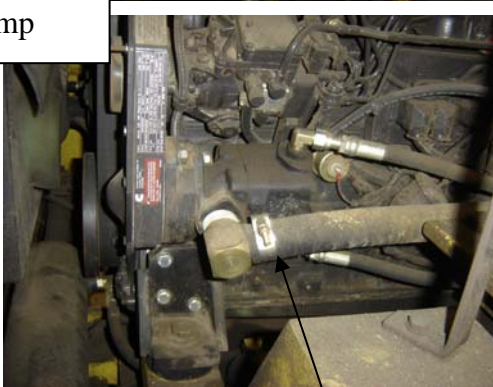
Suction line hose clamps need to be checked for torque during every P.M to ensure proper sealing. A cold rubber hose that is not sealed properly will suck in air, the suction is lost and pump loses prime. That is what causes the pumps to become very noisy.



Suction hose clamp on the main pump



Suction hose clamp on the pumps



Suction hose clamp on the brake pump

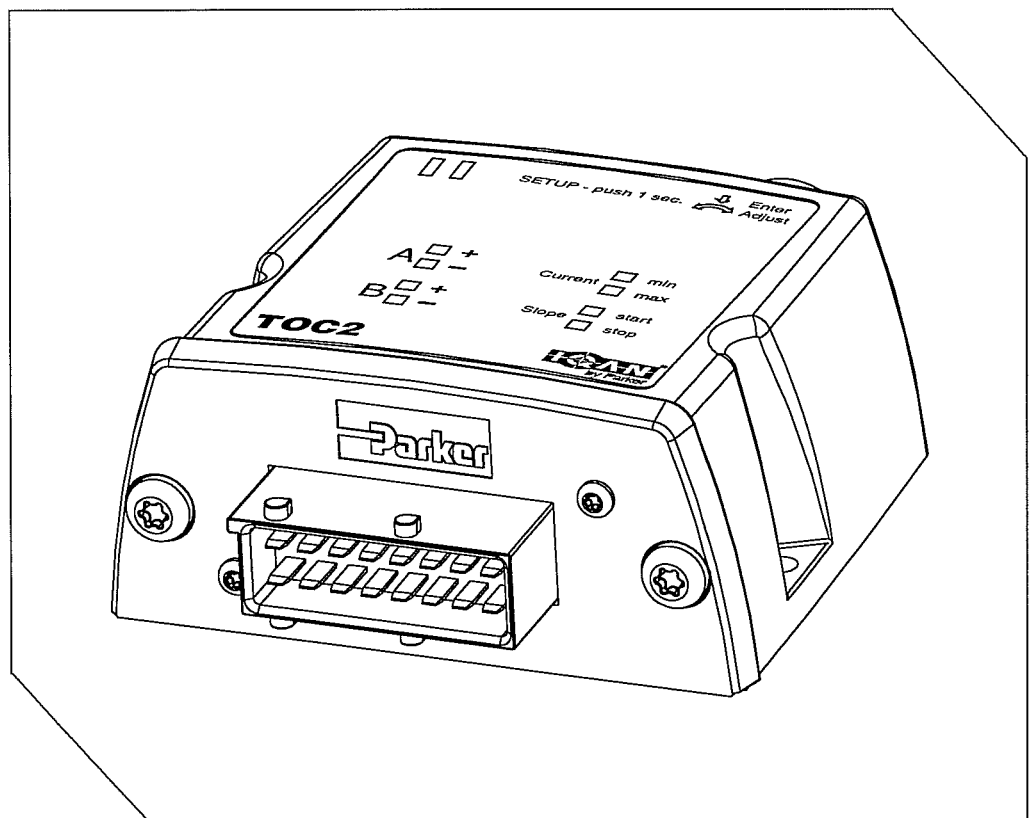


Suction hose clamp on the suction filters



Instruction book IQAN-TOC2

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Edition 0306

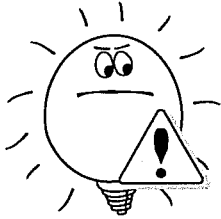


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1 Introduction

These instructions are meant as a reference tool for the vehicle manufacturer's design, production, and service personnel.

The user of this manual should have basic knowledge in the handling of electronic equipment.



ATTENTION

Sections regarding safety, marked with the IQman symbol shown in the left margin, must be read and understood by everyone using the system, carrying out service work or making changes to hardware/software.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

The term, manufacturer, refers to Parker Hannifin Corporation.

2 Precautions

General safety regulations

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine and its safety regulations.

Mounting, modification, repair and maintenance must be carried out in accordance with the manufacturer's regulations. The manufacturer has no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer does not assume any responsibility for the system being incorrectly applied, or for the system being programmed in a manner that jeopardizes safety. Damaged product may not be used. If the control system shows error functions or if the electronic control, cabling or connectors are damaged, the system shall not be used.

Electronic control systems in an inappropriate installation and in combination with strong electromagnetic interference fields can, in extreme cases, cause an unintentional change of speed of the output function.

As much as possible of the welding work on the chassis should be done before the installation of the system. If welding has to be done afterwards, the electrical connections on the system must be disconnected from other equipment. The negative cable must always be disconnected from the battery before disconnecting the positive cable. The ground wire of the welder shall be positioned as close as possible to the place of the welding. The cables on the welding unit shall never be placed near the electrical wires of the control system.

Construction regulations

The vehicle must be equipped with an emergency stop which disconnects the supply voltage to the control system's electrical units. The emergency stop must be easily accessible to the operator. The machine should be built, if possible, so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator's station.

Safety during installation

Incorrectly positioned or mounted cabling can be influenced by radio signals which can interfere with the functions of the system.

Safety during start-up

The machine's engine must not be started before the control system is mounted and its electrical functions have been verified.

Ensure that no one is in front, behind or nearby the machine when first starting up the machine.

Follow the instructions for function control in the Start-up section.

Safety during maintenance and fault diagnosis

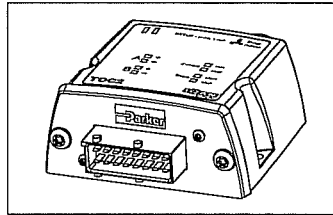
Ensure that the following requirements are fulfilled before any work is carried out on the hydraulics control electronics.

- The machine cannot start moving.
- Functions are positioned safely.
- The machine is turned off.
- The hydraulic system is relieved from any pressure
- Supply voltage to the control electronics is disconnected.

3 Product description

IQAN-TOC2

The IQAN-TOC2 is a stand alone controller designed for controlling hydraulic systems in vehicles and machinery, using 12/24 Vdc power supply.



The IQAN-TOC2 control.

Input

The IQAN-TOC2 control has four(4) inputs. Two are used as *voltage inputs* for connection of 0-5 Vdc signals, VIN A and VIN B. When two control devices (i.e. joysticks) are connected to VIN A and VIN B respectively, the TOC2 can operate up to two directional valve sections.

The other two inputs are *digital inputs*, DIN A and DIN B. The digital inputs may be used in a variety of ways (ie 'output enable' switch).

All inputs, *voltage* or *digital*, may be configured using IQANdevelop software.

Output

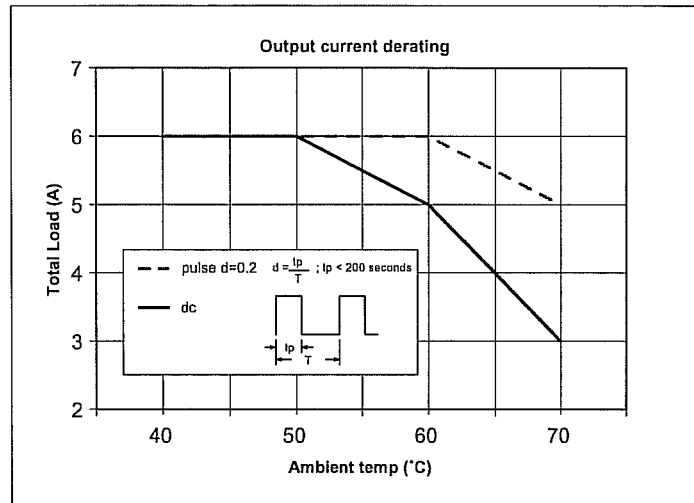
The TOC2 control has two (2) double *proportional outputs* for controlling proportional valves or devices. The unit can control two directional valve sections or two independent single solenoid devices (ie. proportional cartridge valves). The outputs can be used in two different modes. Either *Current mode* (current closed loop) or *PWM mode* (voltage open loop) signals can be selected and the parameters configured using IQANdevelop software.

In order to increase the performance of the proportional outputs when controlling directional valves, the *frequency* can be adjusted using IQANdevelop software.

The *min. output*, *max. output* and *start/stop slopes* are adjustable from the mechanical HMI (human machine interface) and also with IQANdevelop software.

Output derating in high temperatures

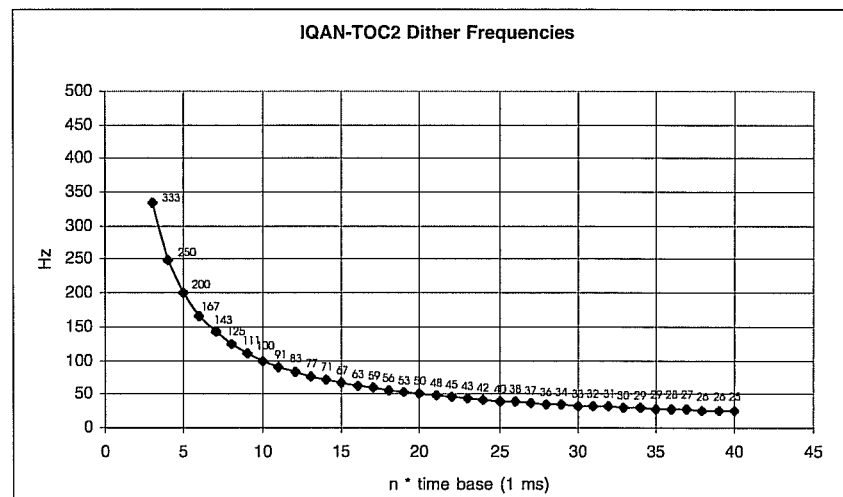
This diagram shows the TOC2 output current derating when the unit is working in high ambient temperatures. Due to internal power dissipation the temperature inside the enclosure will be higher than the ambient air. Maximum current in low temperatures are mainly restricted by the software. The graph below shows the relation between high ambient temperature and total output current (the sum of *COUT-A* and *COUT-B*).



Current derating for the IQAN-TOC2 control.

Dither frequency

This graph shows the TOC2 frequency range. The points are the available output frequencies for proportional valve control.



Possible frequencies for the IQAN-TOC2 control.

RS232 serial communication

Through the RS232 interface it is possible to set and read information stored in the TOC2 using IQANdevelop software.

The serial interface is used for the following:

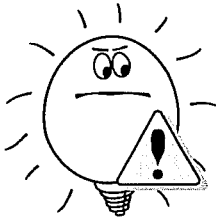
- Downloading a new vmAC (.ido filetype).
- Downloading a new application (.idt filetype).
- Reading or changing stored parameters.
- Reading or clearing error and status counters.

VREF external voltage reference

Voltage reference VREF will supply external sensors and levers with +5V on the +VREF pin. The return line from each sensor or lever is connected to the -VREF pin.

The +VREF signal is protected against short circuit to +BAT, -BAT and short circuit of load. The +VREF output has error detection and if the signal is out of range an error will be activated. During error situations all voltage inputs (VIN A and VIN B) are forced to the pre-defined error value specified in IQANdevelop.

The -VREF signal is not protected against short circuit to +BAT. This failure mode can cause high current that will destroy the module.

**OBSERVE**

Maximum load for the VREF, see Appendix A, on page 27.

4 Safety

General

In order to fulfill safety demands, the TOC2 control memory is checked through check-sum calculations at startup. Memory errors always lead to an immediate shut off of all outputs and the software goes to a fail-safe state.

Input/output Protection

All inputs on the TOC2 control are designed to withstand the maximum specified supply voltage. VIN out of range will generate an error code. DIN errors are not monitored but overvoltage will not affect the other inputs. The outputs are protected against short circuit.

Current mode output

For the *current mode outputs*, a current check is performed. If an error occurs, the user will be notified through an appropriate error code on the unit's LED.

PWM mode output

For the *PWM mode outputs*, no error checking is performed.

Memory test

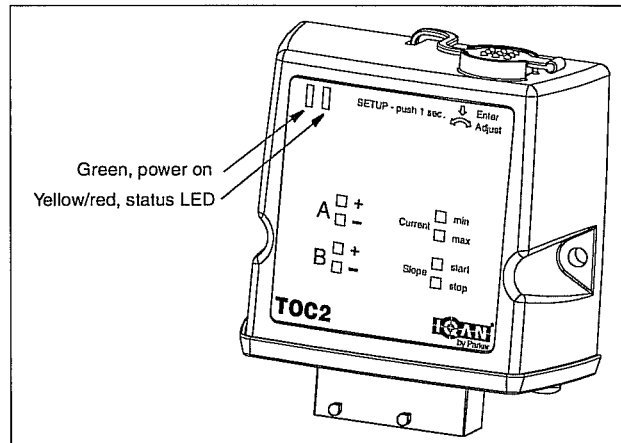
At startup the TOC2 vmAC calculates the checksum of the application (stored in Flash) and the checksum of adjustable parameters (stored in E2prom). If any of these checksums fail, I/O handling will not be allowed, and an error message will be transmitted by the diagnostic lamp. This checksum control will only be performed at startup.

Failure Modes

Type of failure	Comments
VREF	
+VREF open	VIN out of range, will create a VIN error => VIN=Predefined error value
-VREF open	VIN out of range, will create a VIN error => VIN=Predefined error value
+VREF short-circuited to -VREF	VREF error, will shut off outputs
+VREF short-circuited to +BAT	VREF error, will shut off outputs
+VREF short-circuited to -BAT	VREF error, will shut off outputs
-VREF short-circuited to +BAT	External fuse (max 7.5A) on +BAT blows
-VREF short-circuited to -BAT	not detected
VIN	
VIN open	VIN out of range, will create a VIN error => VIN=Predefined error value
VIN short-circuited to +BAT	VIN out of range, will create a VIN error => VIN=Predefined error value
VIN short-circuited to -BAT	VIN out of range, will create a VIN error => VIN=Predefined error value
DIN	
DIN open	not detected
DIN short-circuited to +BAT	not detected
DIN short-circuited to -BAT	not detected
Current mode	
COUT open	COUT error will shut off output
CRET (active) open	COUT error will shut off output
CRET (passive) open	not detected, will not affect function
COUT short-circuited to CRET (active)	COUT error will shut off output
COUT short-circuited to CRET (passive)	not detected, will not affect function
COUT short-circuited to +BAT	COUT error will shut off output
COUT short-circuited to -BAT	COUT error will shut off output
CRET (active) short-circuited to +BAT	COUT error will shut off output
CRET (active) short-circuited to -BAT	not detected, will not affect function
CRET (passive) short-circuited to +BAT	not detected, will not affect function
CRET (passive) short-circuited to -BAT	COUT error will shut off output
COUT short-circuited to 2nd COUT (active)	COUT error on one of the outputs (indeterministic function)
COUT short-circuited to 2nd COUT (passive)	not detected, will not affect function
COUT short-circuited to 2nd CRET (active)	COUT error will shut off output
COUT short-circuited to 2nd CRET (passive)	not detected, will not affect function
CRET short-circuited to 2nd CRET (active)	COUT error will shut off output
CRET short-circuited to 2nd CRET (passive)	not detected, will not affect function
Insufficient voltage	COUT error will shut off output
H-side short-circuited to 2nd H-side (active)	

System Diagnosis

The yellow blinking LED on the top of the unit indicates normal status. The TOC2 control indicates *error status* through the red blinking LED and a yellow secondary blinking pattern, as shown below. This gives an immediate indication as to the cause of an error.



The location of the LED indicators on the IQAN-TOC2 control.

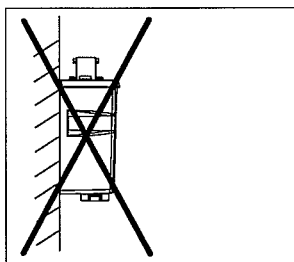
The green LED indicates power on. The yellow/red LED, will be blinking a pattern when an error has been detected or during certain operations. To get further information about the error messages, see Appendix B, on page 30.

5 Mounting

Mounting the unit

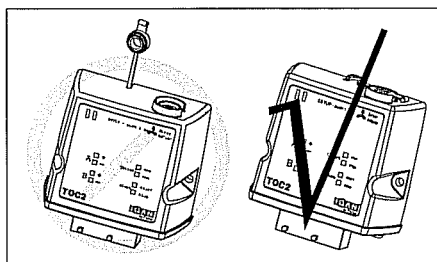
The IQAN-TOC2 control should be mounted according to the following instructions:

- Locate the unit eliminating the risk for the cabling to be folded, crushed or damaged in any way. Ensure the cabling cannot pull, twist or induce sideload on the connector.
- Locate the unit so that severe physical impact is avoided, e.g. impact from falling objects or the unit being used as a step.
- Locate the unit so that air can circulate to eliminate excess heat. Ensure that no external heat, e.g. from the engine or heater, is transferred to the control.
- Locate the unit to protect it from high pressure washing or similar.
- Locate the unit so that the cable connector is facing down.
- Locate the unit so that the HMI is accessible.
- Locate the unit so that the LEDs are visible.



Non-approved placing.

The rubber cap covering the HMI adjustment access hole must always be replaced to protect the unit.

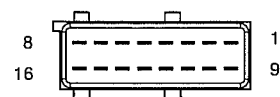


Always replace the rubber cap.

6 Installation

Connector C1

Connector kit	Parker no. 5031105
Housing	Amp no. 1-963217-1
Plane sealing, 16 p	Amp no. 963216-1
Pin type	Amp no. 929939-1
Cables	0,75-1,0 mm ²
Seals	Amp no. 828904-1
Plugs (empty pos.)	Amp no. 828922
IQAN toolkit	Parker no. 5031061



The IQAN tool kit is found in the 'IQAN accessories' datasheet.

Pos	Signal name	Pos	Signal name
1	+BAT (12V, 24V)	9	-BAT
2	CRET-A+	10	CRET-B+
3	CRET-A-	11	CRET-B-
4	COUT-A	12	COUT-B
5	DATA-OUT	13	DATA-IN
6	DIN-A	14	DIN-B
7	+VREF	15	-VREF
8	VIN-A	16	VIN-B

Supply voltage

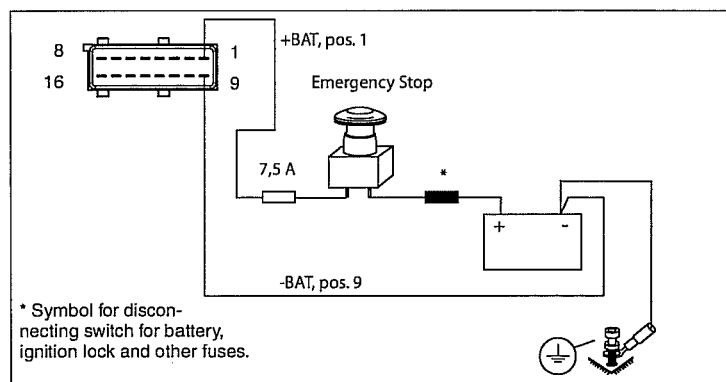
Before any installation of the IQAN system can take place, make sure the ignition lock is turned off and the battery is disconnected.

Emergency stop

Make sure an *Emergency Stop* disconnecting the power supply, is easily accessible at any time. Further relevant regulations are to be found in Machinery Directives 9837/EC. The figure below shows how to connect the emergency stop.

Connecting of Supply Voltage

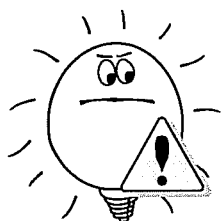
The supply voltage, should be within the operating interval, see Appendix A, on page 27. Connect the supply voltage to +BAT, position 1 and -BAT, position 9. Reverse voltage protection for the control is provided by using a fuse. Requisite fuse level should be 7,5 A.



Connecting the emergency stop and voltage supply.

OBSERVE

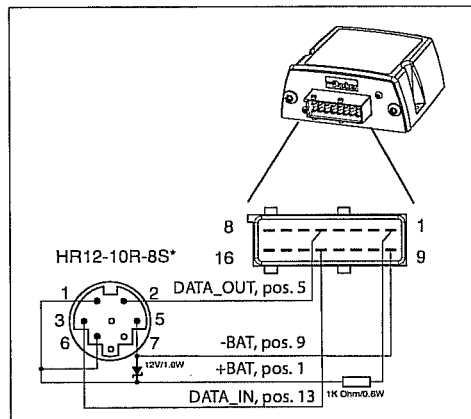
Do not use the chassis as the negative terminal.



RS232 connection

The TOC2 control has an *RS232 interface* for communicating with the programming software, IQANdevelop. A flying lead cable, 5030089 may be connected to the TOC2 to provide an HR12 connector interface. The connection from TOC2 to PC can be made with cable 5030024 and from TOC2 to PalmOS PDA with the cable 5030096.

Instead of Parker cable 5030089, the recommended wiring to a Hirose HR12 series receptacle is shown below.

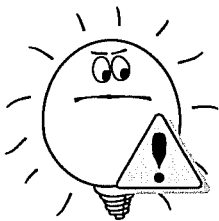


Connecting for RS232.

OBSERVE

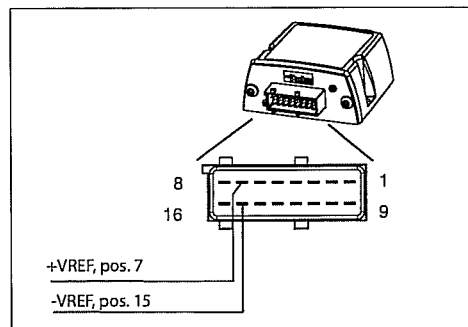
The 'PDA Diagnostic' cable 5030096 must be used when connecting a PalmOS PDA to the TOC2. The palmtop device will also need its hot-sync cable.

Use of the MDM-RS232 cable 5030024 may damage the palmtop device.



Reference voltage, VREF

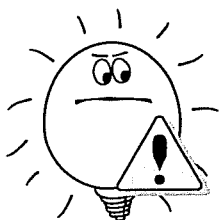
The TOC2 control is internally equipped with a voltage regulator to generate the reference voltage *VREF*. This reference voltage will feed different kinds of joysticks, potentiometers or sensors.



VREF position.

OBSERVE

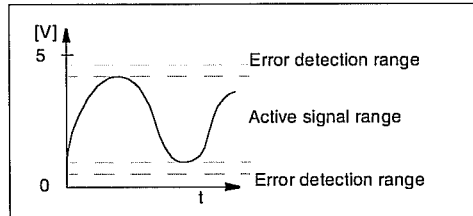
Maximum load for the VREF is different according to 12/24 Vdc power supply, see Appendix A, on page 27.



Voltage inputs

Connecting joysticks to the voltage inputs

The joystick output range must be within 0-5 Vdc. To detect signal errors such as short circuits or interruptions the active signal range should be within 0.5-4.5 Vdc.



Active signal range.

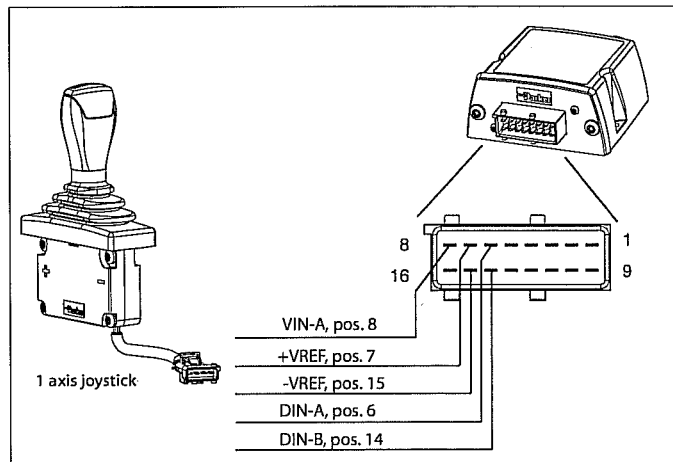
The connection examples are based on the factory default application.

Connecting a single output joystick to voltage in

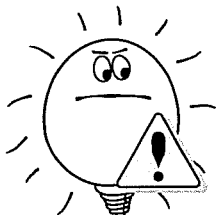
The positive terminal of the joystick is connected to the +VREF position and the corresponding negative terminal to the -VREF position. The joystick output signal is connected to the appropriate VIN position. DIN-A is connected to the DOUT signal from an 'operator present' switch or to +BAT. DIN-B is connected to +BAT.

EXAMPLE

Connect the positive and negative terminals of the joystick to +VREF, position 7, and -VREF, position 15, respectively. Connect the joystick 0.5-4.5V output signal to VIN-A, position 8 and DOUT or +BAT to DIN-A, position 6. Connect +BAT to DIN-B, position 14.



Connecting VREF and joystick signal VIN-A.



OBSERVE

The negative terminal of the joystick must not be connected to the chassis.

Maximum load for the VREF position see Appendix A, on page 27.

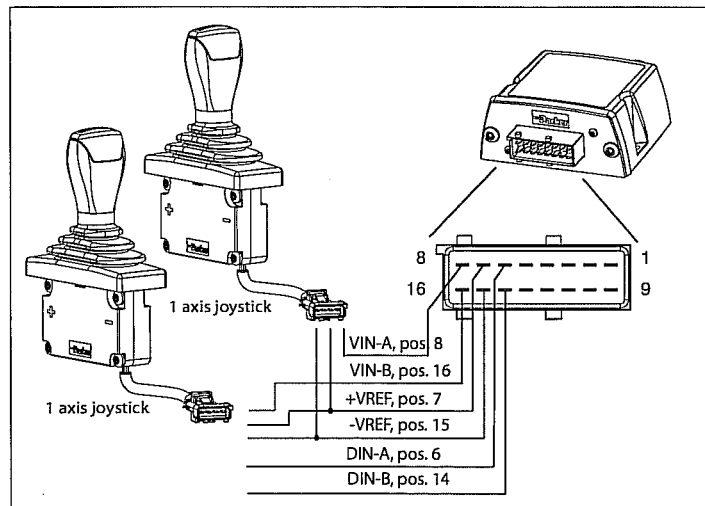
Connecting two single output joysticks to voltage in

When you connect two joysticks to the TOC2, you will use both VIN A and VIN B input signals. Output A will be controlled by the joystick output connected to VIN A and Output B will be controlled by the joystick output connected to VIN B. Two valve sections can be controlled when using two single output joysticks.

The positive terminal of each joystick is connected to the +VREF position and the corresponding negative terminal is connected to the -VREF position. The joystick output signals are connected to the appropriate VIN positions. DIN-A is connected to the paralleled DOUT signals from the joystick 'operator present' switches or to +BAT. DIN-B is connected to +BAT

EXAMPLE

Connect the positive and negative terminals of each joystick to +VREF, position 7, and -VREF, position 15, respectively. Then connect the first joystick 0.5-4.5V output signal to VIN-A, position 8 and connect the second joystick 0.5-4.5V output signal to VIN-B, position 16. Connect the DOUT's or +BAT to DIN-A, position 6. and connect +BAT to DIN-B, position 14.

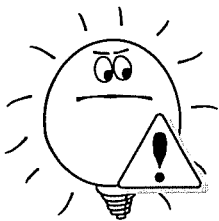


Connecting VREF and two joystick signals to VIN-A and VIN-B.

OBSERVE

The negative terminals of the joysticks must not be connected to the chassis.

Maximum load for the VREF position, see Appendix A, on page 27.



Connecting a two axis joystick to voltage in

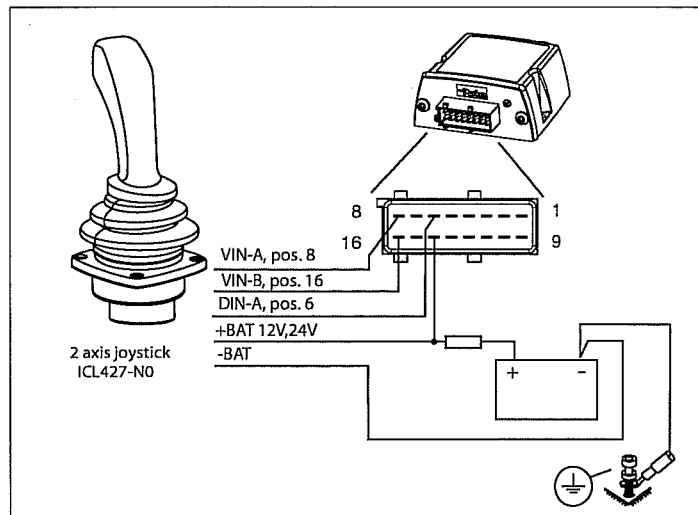
When you connect a two axis joystick to the TOC2, you will use both VIN A and VIN B input signals. Output A will be controlled by the joystick output connected to VIN A and Output B will be controlled by the joystick output connected to VIN B. Two valve sections can be controlled when using a two axis joystick.

The Parker ICL4 and ICM4 joysticks do not use the +VREF position or the -VREF position. Power supply to this type of joystick is from +BAT and -BAT. The joystick output signals are connected to the appropriate VIN position. DIN-A is connected to the DOUT signal from an 'operator present' switch or to +NPO. DIN-B is connected to +BAT

EXAMPLE

Connect the positive and negative terminals of the joystick to +BAT and -BAT respectively. See installation sheet 9129 8323 02.

Connect the first axis 0.5-4.5V output signal to VIN-A, position 8 and connect the second axis 0.5-4.5V output signal to VIN-B, position 16. Connect the DOUT or +NPO to DIN-A, position 6 and connect +BAT to DIN-B, position 14.



Connecting dual axis joystick signals to VIN-A and VIN-B.

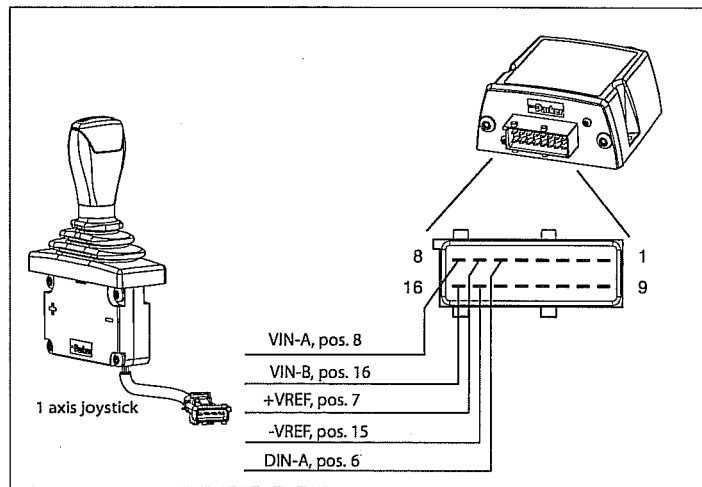
Connecting a single axis, dual output joystick to voltage in

You would connect a dual output joystick for the highest degree of safety. Since this type of joystick uses error checking, you use both VIN-A and VIN-B input signals. The second output from the joystick is inverted (4,5V - 0,5V). Only a single valve section can be controlled when using a dual output joystick.

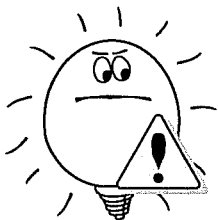
The positive terminal of the joystick is connected to the +VREF position and the corresponding negative terminal is connected to the -VREF position. The joystick output signals are connected to the appropriate VIN position. DIN-A is connected to the DOUT signal from an 'operator present' switch or to +BAT..

EXAMPLE

Connect the positive and negative terminals of the joystick to +VREF, position 7, and -VREF, position 15, respectively. Then connect the joystick output A signal to VIN-A, position 8 and connect the joystick output B signal to VIN-B, position 16. Connect DOUT or +BAT to DIN-A, position 6.



Connecting VREF and dual output joystick signals to VIN-A and VIN-B.



OBSERVE

The negative terminal of the joystick must not be connected to the chassis.

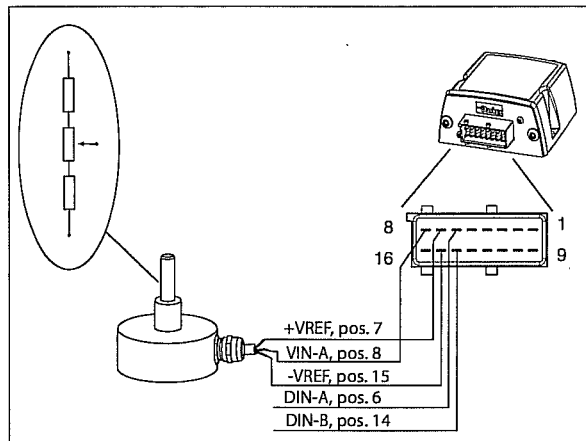
Maximum load for each VREF position, see Appendix A, on page 27.

Connecting potentiometers to the voltage inputs

Potentiometers could be connected to the voltage inputs, to provide a rotary control to generate the input signal. The potentiometer may be connected to +VREF, VIN and -VREF respectively. DIN-A is connected to the DOUT signal from an 'operator present' switch (ie. footswitch or seat switch) or to +BAT. DIN-B is connected to +BAT.

EXAMPLE

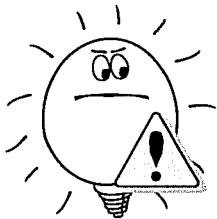
Connect the positive and negative terminals of the pot to +VREF, position 7 and -VREF, position 15 respectively. Connect the output (or wiper) to VIN-A, position 8 and DOUT or +BAT to DIN-A, position 6. Connect +BAT to DIN-B, position 14.



Connecting a pot to VIN-A.

OBSERVE

Maximum load for VREF, see Appendix A, on page 27.



Proportional outputs

The current /PWM outputs control proportional valves and devices. Maximum load should not exceed 150 Ω . For the current range see Appendix A, on page 27.

Frequency

To obtain the best performance from proportional valves the control produces a current mode (closed loop) output signal or a PWM voltage (open loop) output signal. The type of output is selectable in IQANdevelop. The units have an adjustable frequency which can be changed using IQANdevelop.

Connecting loads to proportional outputs

Connecting a load, e.g. one proportional valve section, to the current mode or PWM mode outputs is done by using the COUT/CRET pair positions.

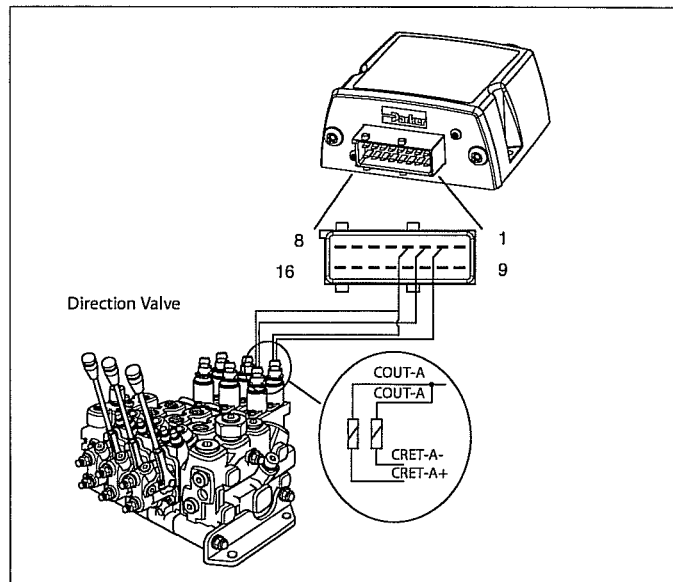
EXAMPLE

Positive direction:

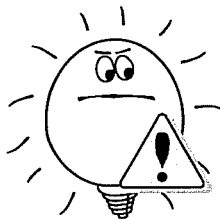
Connect the proportional valve to the COUT-A, position 4 and the CRET-A+, position 2 respectively.

Negative direction:

Connect the proportional valve to the COUT-A, position 4 and the CRET-A- , position 3 respectively.



Connecting a load to proportional output COUT A.



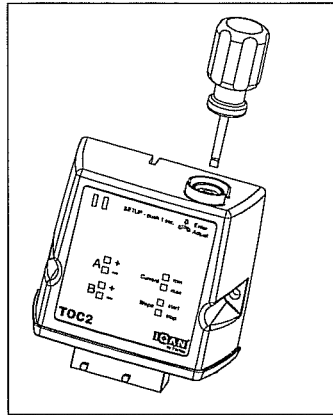
OBSERVE

Do not install diodes across coils for Current or PWM modes!

Do not exceed 150 Ω load on outputs.

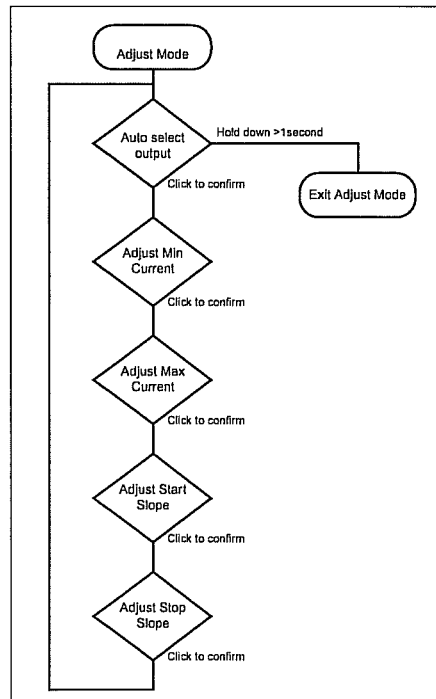
HMI Human Machine Interface

The TOC2 control has a mechanical interface for adjusting the min., max. and ramp properties of the outputs. Only properties that are set as adjustable in the application can be adjusted. Access to the mechanical encoder is shown below.



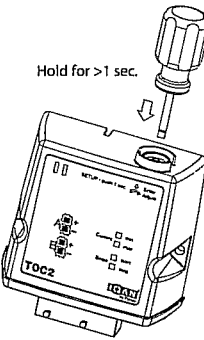
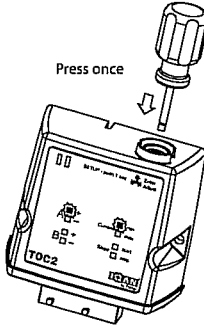
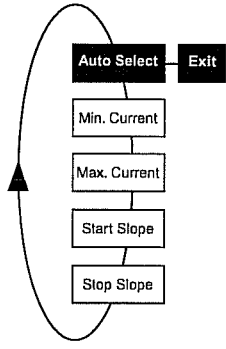
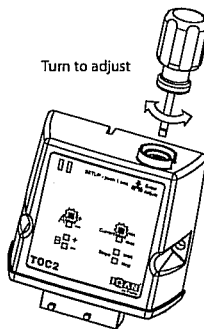
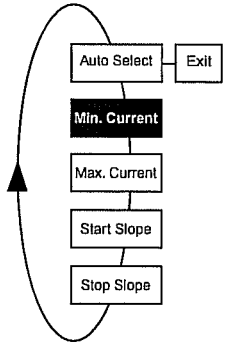
Location of TOC2 HMI.

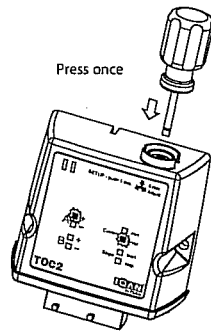
The adjustment mode is entered by pressing the pushbutton for more than 1 second. The unit will then wait for an output to be activated by the user (auto-select). After the user confirms the output selection by a click on the pushbutton, all adjustments will be done on the selected output. During adjustment all other outputs work normally to make fine tuning of a function easier. When adjustments are completed the pushbutton is pressed for a longer period (>1 second) and the unit will change back to operating mode



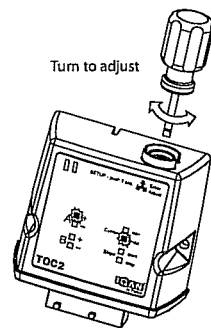
Flowchart for adjustment procedure on TOC2.

Adjustment procedure

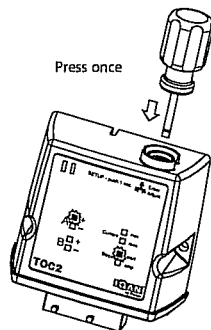
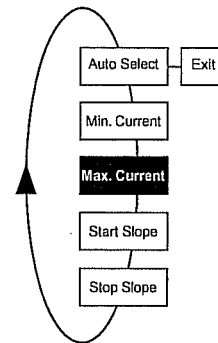
Action at TOC2	Description	Mode
	<p>The TOC2 must be connected to +BAT before adjusting.</p> <p>Remove the protective rubber cap to access HMI.</p> <p>Using a small screwdriver, press the slotted pushbutton shaft and hold for more than one second. This enters adjustment mode. The A and B +/- LED's will flash to show the unit is in adjustment mode.</p>	
	<p>Activate the control (lever, joystick, potentiometer...) for the function you want to adjust in order to auto-select. The LED for the proper channel and direction will flash at the TOC2. Press the pushbutton to confirm your selection. The flashing LED will change to a steady on state and the min current LED for the selected channel will light.</p>	
	<p>To change the min current setting, use your screwdriver to turn the slotted shaft. Activate your control (lever, joystick, potentiometer...). When adjusting the min value the selected function is not allowed to exceed the min setting, regardless of the control position. Turning the shaft clockwise will increase the min current and counter-clockwise will reduce the min current.</p>	



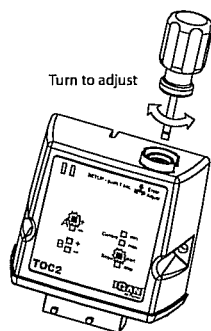
When you are finished adjusting the min current or if you do not need to adjust the value, you may press the pushbutton to go on to the next step. The max current LED for the selected channel will light.



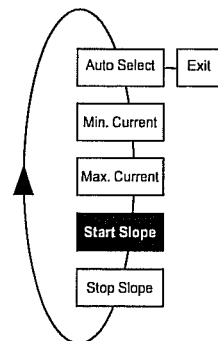
To change the **max current** setting, use your screwdriver to turn the slotted shaft. Activate your control (lever, joystick, potentiometer...). When adjusting the max value the selected function is allowed to move at the max setting and the min current setting is active. Turning the shaft clockwise will increase the max current and counter-clockwise will reduce the max current.

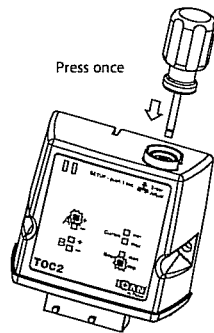


When you are finished adjusting the max current or if you do not need to adjust the value, you may press the pushbutton to go on to the next step. The start slope LED for the selected channel will light.

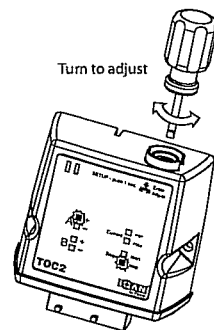


To adjust the **start slope** setting, use your screwdriver to turn the slotted shaft. When adjusting the start slope the function is allowed to move at the max setting and the min current setting is active. Turning the shaft clockwise will increase the start slope time and counter-clockwise will reduce the start slope time. Activate your control to check the start slope after each adjustment.

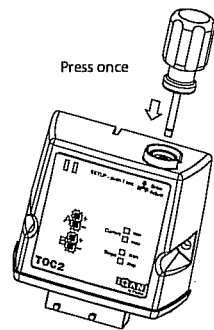
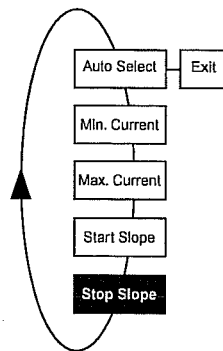




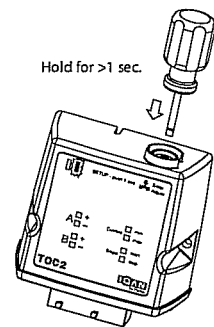
When you are finished adjusting the start slope or if you do not need to adjust the value, you may press the pushbutton to go on to the next step. The stop slope LED for the selected channel will light.



To adjust the **stop slope** setting, use your screwdriver to turn the slotted shaft. When adjusting the stop slope the function is allowed to move at the max setting and the min current setting is active. Turning the shaft clockwise will increase the stop slope time and counter-clockwise will reduce the stop slope time. Activate your control to check the stop slope after each adjustment.

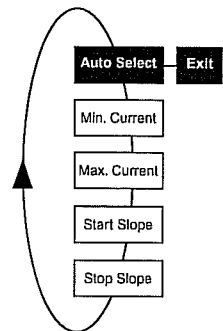


When you are finished adjusting the stop slope or if you do not need to adjust the value, you may press the pushbutton to go on to the next step. This was the last adjustment for the selected channel and direction, so the A and B +/- LED's will flash once more to show that the unit is in adjustment mode



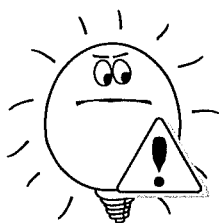
To adjust a new channel or direction, activate the control for the function you want to adjust in order to auto-select. Then repeat the adjustment steps. If adjustment is complete, press the slotted pushbutton shaft and hold for more than one second. This exits adjustment mode.

You may only exit adjustment mode from the Auto Select step. Be sure to replace the protective rubber cap.



7 Start-up

Start-up procedures



This chapter contains instructions for action to be taken in connection with the initial start, for example, setting values, calibrating and testing the system.

OBSERVE

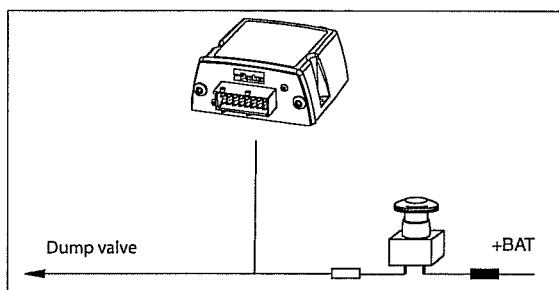
Risk of injury!

If the control system is not fitted properly, the machine could move uncontrollably. The machine's engine shall not be started before the control system is completely fitted and its signals are verified.

Starting the control system

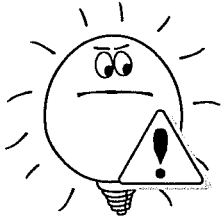
Start the control system as follows:

- Prior to start, the control and cables are to be fitted correctly.
- Check fuses, i.e. make sure that the supply voltage to the unit is equipped with the correct fuse.
- Make sure that connections for supply voltage and return lines are correct in the cable's conductor joint.
- Make sure the emergency stop works.
The emergency stop should disconnect the supply voltage to the control.



Emergency stop.

Alternatively, the emergency stop may also shut off the diesel engine or a dump valve, and depressurize the hydraulic system.



Prepare for system start

OBSERVE

Make sure no one is in dangerous proximity to the vehicle, to avoid injuries when it starts.

Prepare for the initial system start as follows:

- The engine for the hydraulic system's pump shall be in off position.
- Make sure that all connectors are properly connected.
- Turn on the control system.
- Make sure that voltage is being supplied to the control, the green diode will be illuminated on the unit.
- Make sure the emergency stop is functioning properly.

Start the system

Start the system as follows:

- Start the engine for the hydraulic system's pump, assuming that the above mentioned inspections have been carried out and shown correct values.
- Calibrate and adjust input and output signals according to the instructions and check every output function carefully.
- In addition to these measures, the machine shall also meet the machine directives for the country in question.

Appendix A

IQAN-TOC2 Technical Overview

Absolute maximum ratings

$T_A = +25\text{ }^{\circ}\text{C}$ (unless otherwise specified)

Parameter	Limit values			Unit	Remark
	min.	typ.	max.		
Operating ambient temperature, T_A	- 40		+70	$^{\circ}\text{C}$	
Storage temperature	- 40		+100		
Voltage supply, V_{BAT}	6		36	V	reverse polarity protected with 7.5A fuse
Analog input levels, V_{IN}			36	V	short circuit protected
Digital input levels, D_{IN}			36	V	short circuit protected
+VREF			36	V	short circuit protected (-VREF not over-current protected)
RS232			36	V	short circuit protected
Load current, total all outputs			6	A	

Environmental ratings

Parameter	Limit values			Unit	Remark
	min.	typ.	max.		
EMI					
ISO 14982:1998				Mhz	30-1000 Mhz
EN 55022:1998				Mhz	0.15-30 Mhz
ISO 11452-2:1995			100	V/m	20-1000 Mhz
ISO 11452-4:1995			150	mA	1-200 Mhz
ISO 7637-3			80	V	
EN61000-4-8			100	A/m	
ESD					
EN 61000-4-2 (external)			15	kV	
Mechanical environment					
IEC 68-2-64 Fh (random, 10 - 250 Hz)			0.1	g^2/Hz	10-20 Hz
			0.4	g^2/Hz	20-250 Hz
IEC 68-2-29 Eb (bump, 6ms)			40	g	
Climate environment					
IEC 68-2-18 Rb3 (water)			3	min.	30kPa, 12.5 l/min.
IEC 68-2-30 Db (var1: damp, cyclic)			72	hour	25-55°C, 95% RH
IEC 68-2-3 Ca (damp, heat steady state)			240	hour	44°C, 93% RH
IEC 68-2-2-Bb (heat)			72	hour	70°C
IEC 68-2-1 Ab (cold)			16	hour	-40°C
IEC 68-2-14 Nb (change of temperature)			10 x 6	hour	-40 to 70°C
Chemical environment					
IEC 68-2-52 Kb (salt mist, cyclic)			72	hour	

Operation

-40 °C < T_A < +70 °C (unless otherwise specified)

Parameter	Limit values			Unit	Remark
	min.	typ.	max.		
Ambient temperature (no load), T _A	- 40		+70	°C	
Voltage supply, V _{BAT}	9		34	V	
Startup delay		250		ms	
Dither frequency	25		333	Hz	
Output voltage, VREF	4.9	5.0	5.1	V	
Maximum load current, VREF V _{BAT} = 14V V _{BAT} = 28V			50 30	mA	
Current supply V _{BAT} = 14V V _{BAT} = 28V		40 55		mA	outputs = off, no load on VREF

Input

-40 °C < T_A < +70 °C (unless otherwise specified)

Parameter	Limit values			Unit	Remark
	min.	typ.	max.		
VIN (Voltage input)					
Signal range low		0	0.05	V	
Signal range high	4.9	5.0	5.1	V	
Input resistance		62		kΩ	
Signal resolution		5		mV	
Total unadjusted error		15	35	mV	(VREF as source)
DIN (Digital input)					
Input level low			1.0	V	
Input level high	4.0			V	
Input hysteresis		1.7		V	
Input resistance		5.6		kΩ	

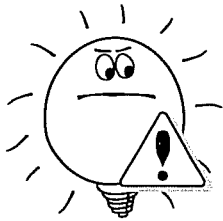
Output

-40 °C < T_A < +70 °C (unless otherwise specified)

Parameter	Limit values			Unit	Remark
	min.	typ.	max.		
COUT (Current mode)					
Signal range	50		3000	mA	
Voltage drop (VBAT- VCOUT) Load = 0.5A Load = 3A		0.2 0.8		V	
Short circuit current limit		6		A	
Linearity error		10		mA	TA= 25°C 50mA to 1500mA
Temperature error		10		mA	TA= -40° to 70°C 50mA to 1500mA
Power supply rejection VBAT= 9... 18V VBAT= 24... 34V		1 1		mA	RL=6 Ω –25 Ω (RL: Resistance of connected load)
Load regulation VBAT=14V, RL=4... 9 Ω VBAT=28V,RL=22... 34 Ω		1 1		mA	
Dither frequency	25		333	Hz	
Resolution		1		mA	Dependent on load, power supply and dither frequency
PWMOUT (PWM mode)					
Modulation ratio (MR) low		5		%	
Modulation ratio (MR) high		95		%	
Load current, each active channel (A/B)			3000	mA	
Voltage drop (VBAT- VCOUT) Load = 0.5A Load = 3A		0.2 0.8		V	
Short circuit current limit		6		A	
Dither frequency	25		333	Hz	
Resolution		1		%MR	

Appendix B

Error codes



If one of the following errors is detected, a message will be presented via the LED error codes on the control. In some cases, the control will stop operating or at least shut down the outputs, to increase safety. Possible failure modes are listed on page 9.

OBSERVE

Do not use the machine if an error message or error code is activated. The following sections will present what measures to take for different error situations.

LED indicator showing different TOC2 modes

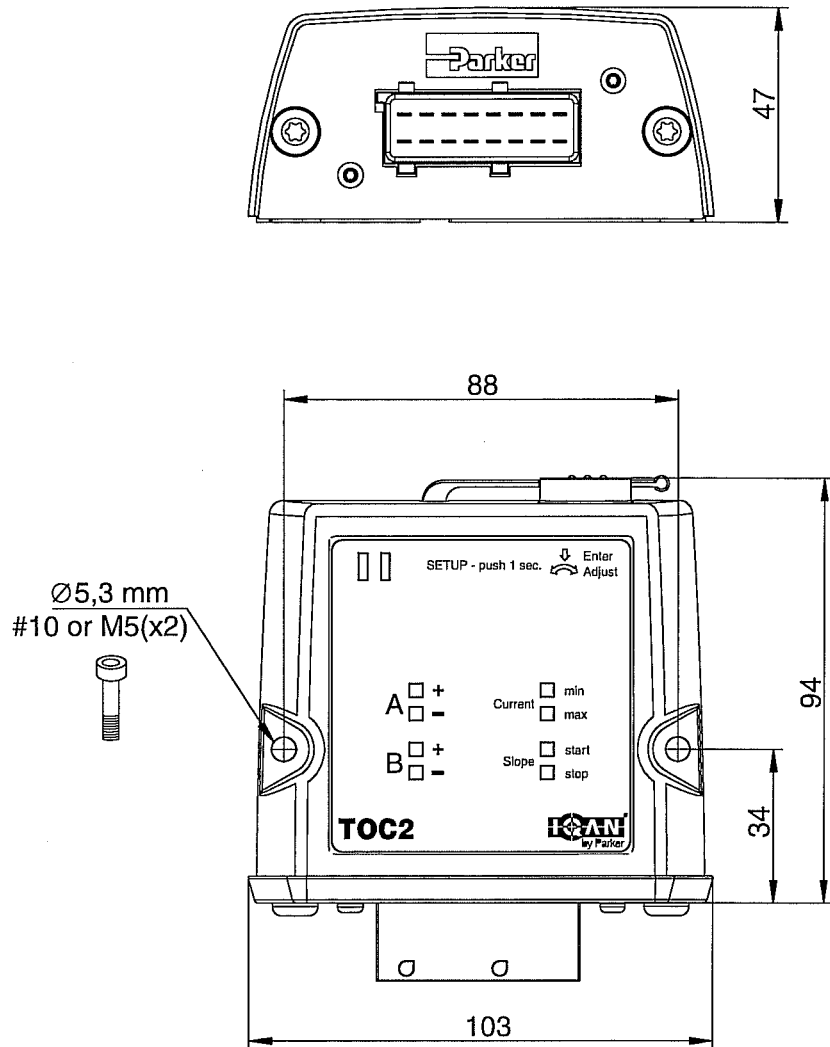
Status	Blink (yellow light)
Normal operation	
Downloading	
BSL ^a power on (yellow/red)	
BSL waiting for download (yellow)	

a.BSL stands for "boot strap loader" mode. This mode is used to download a new vmAC.
To enter BSL mode, the HMI pushbutton is held down during power-up.

Error code	Error	Primary Blink (red) Error category	Secondary Blink (yellow) Error description
1-1	Output error		
1-2	Input error		
1-3	VREF error		
IA	Invalid application		
FE	Fatal error (red, steady)		

Appendix C

Dimensioning of the IQAN-TOC2 module



Unit = mm

Adjustment for FKS series

The system has a 100cc PAVC pump and a Pulsar valve to control the mast. This pump also provides pressure for the brakes and steering.

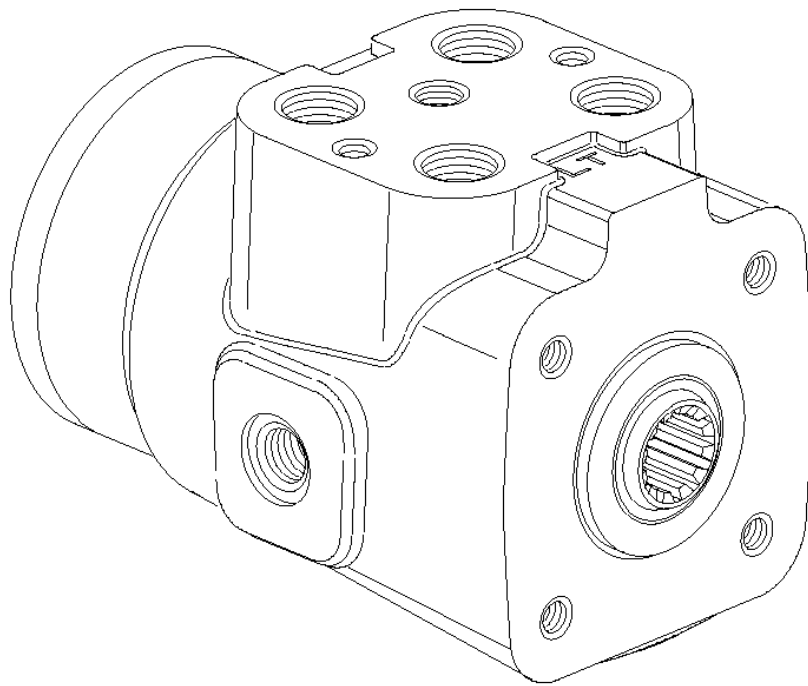
To set the system up make sure the oil level is to the full mark with the mast lowered.

1. Check oil level
2. Place a pressure gauge at the outlet of the pump (minimum 3000 PSI range)
3. Start the engine
4. Cycle the brake pedal until the charge valve cycles to fill the accumulator.
5. The pressure gauge should rise to 2400-PSI +/- 150 PSI and then drop to 500 PSI.
6. If the charge will not fill and cycle brake to standby of 500 PSI the max pressure of the pump needs to be adjusted or the brake valve is defective.
7. The main pump pressure needs to be 100 to 200 PSI above the 2400 PSI steer pressure to satisfy the priority. This can be checked in the same manner and gauge position by tilting full forward or back and checking gauge.
8. To set the pump loosen the jam nut on the compensator on the bottom side of the pump and adjust it inward (clockwise) to a pressure that the brake charge valve cycles but do not exceed 3000 PSI.
9. If the brake valve will not cycle at this setting the valve is defective.
10. After you have reset the pump cycle the brakes several times to make sure they are working correctly.
11. Check the function of the joysticks, if you have a problem start at the valve with a ½" wrench and activate the spools manually to determine if the problem is electrical or hydraulic.
12. If the functions work manually then start by looking at the control card at the Green and Yellow/Red LED lights. The Yellow LED indicates normal status. Red LED indicates error.
13. The green lights should come on when the joystick is pulled one way and the other green light should go on when the stick is moved in the opposite direction. If they don't you do not have input from the joystick.
14. If you do not have the green lights there should be a Red light that indicates output on the card, if you have Red light coming on the next step is to go to the connector at the valve.
15. Put a test light on the two-wire lead and move the joystick, the light should light.

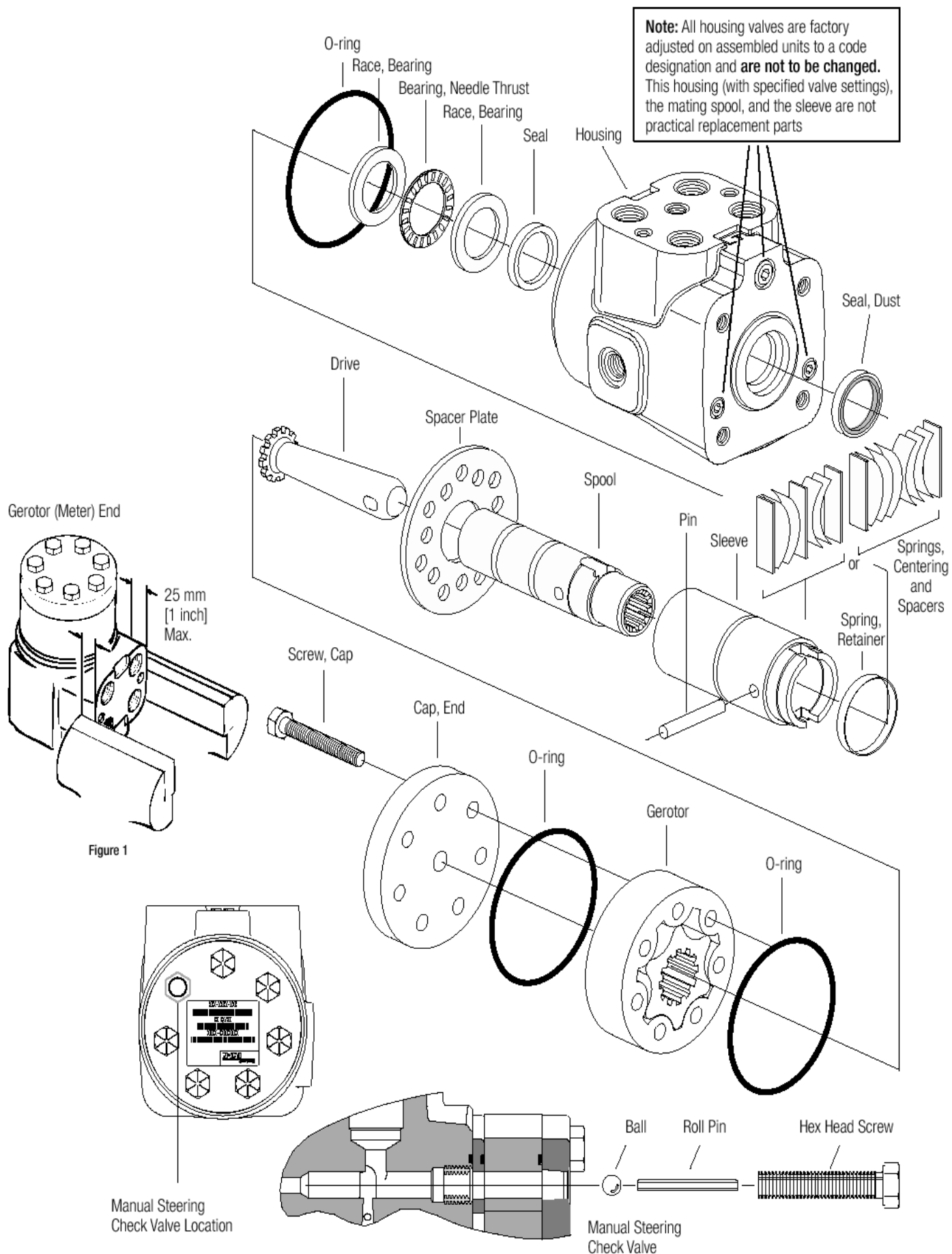
Reference, IQAN-TOC2 Instruction for further adjustments and trouble-shooting.

HOIST LIFTRUCK
MFG., INC.

ORBITROL REPAIR
MANUAL
H00999 AND H00462



Disassembly/Reassembly



Disassembly/Reassembly

Cleanliness is extremely important when repairing a steering control unit. Work in a clean area. Before disconnecting lines, clean port area of unit thoroughly. Use a wire brush to remove foreign material and debris from around exterior joints of the unit.

Although not all drawings show the unit in a vise, **we recommend** that you keep the unit in a vise during disassembly and reassembly. Follow the clamping procedures.

Notice placement of check ball and roll pin (manual steering check valve), the cap screw that retains these parts should be removed first. Safely retain these parts and remember to reinstall these parts last at reassembly.

1 Clamp unit in vise, meter end up. Clamp lightly on edges of port face sides (see figure 1). Use protective material on vise jaws. Housing distortion could result if jaws are overtightened.

2 Carefully disassemble steering control unit in this vertical position as shown in figure 2 (**if not kept vertical**), the pin that links the sleeve, spool, and drive could possibly slip and like a dead bolt it will lock these parts in the housing before it is completely out.

Requirement

Assure that all parts are free from rust, other contaminants, nicks and burrs at time of reassembly.

Lubricate o-ring seals with Mobilith SCH 220 high temperature grease. (If the o-ring seals used in meter section are lubricated with petroleum jelly for assembly purpose, the amount of petroleum jelly used should be minimal to avoid spreading the grease on the surfaces that form the interfaces between end cap and gerotor ring and between gerotor ring and spacer plate).

Reassembly Requirements

3 Sealing lips/surfaces of shaft seal shall be protected against deforming, cutting or abrasion during installation. Sealing surface area of shaft must be free from scratches, dents, and other defects detrimental to seal performance and life.

4 Spool must rotate smoothly inside sleeve with less than 0,11 Nm [1 lb-in] torque (fingertip force) when both parts are lubricated with hydraulic fluid.

5 Installation of spring spacers and springs, hold spring retainer at an angle as shown (see figure 3 reference number 1), insert spring spacers and springs one at a time in sequence noted by reference numbers 2 - 9 (Standard torque), 2 - 8 (medium torque), then position spring retainer correctly over all these parts. Adjust alignment of spring parts with a small screwdriver.

6 Timing of drive with respect to gerotor star is critical. Pin slot in drive must be aligned with valley (minor diameter) of gerotor star contour.

7 Sleeve must rotate smoothly inside housing with less than 0,17 Nm [1.5 lb-in] torque when both parts are lubricated with hydraulic fluid.

Recommended Torquing Procedure

8 Torque all cap screws to 11-17 Nm [100-150 lb-in] evenly, then to final torque in sequence shown (figure 5) to 31-37 Nm [275-325 lb-in].

Note: Seven cap screws for meter section should be torqued evenly with less than 5% variation (see figure 5). Tightening torque variation between 31-37 Nm [275-325 lb-in] to satisfy travel limit slip rate and input torque requirements (see figure 6) is permissible.

9 When input drive at spline is rotated, gerotor star shall rotate smoothly with less than 60% of torque specified in figure 6 after reassembly and tightening of the seven cap screws to final torque level per Step 8.

10 Completed assembly should rotate smoothly with less input torque than the values specified in the final test specifications (see figure 6) when warmed to 60-66° C [140-150° F].

11 Housing meter (gerotor) end, spacer plate, gerotor ring and end cap shall form pressure tight (zero leakage at 275 bar [4000 PSI]) interfaces after reassembly and tightening of the seven cap screws to final torque level per Step 7.

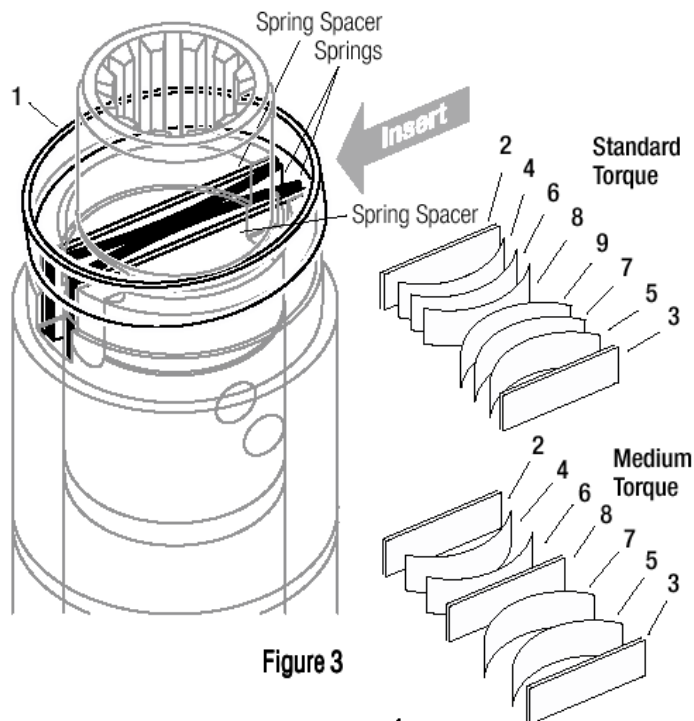


Figure 3

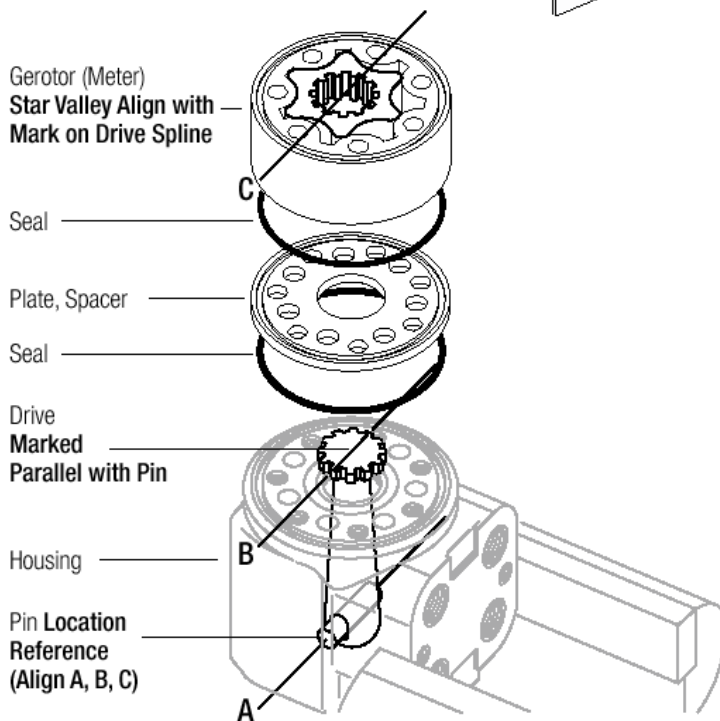


Figure 4

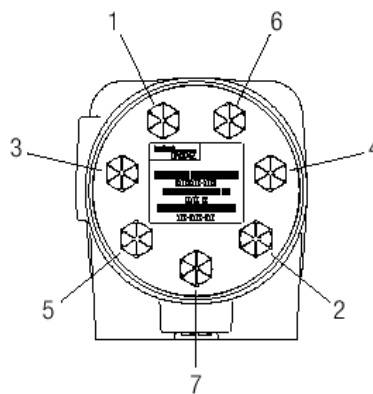
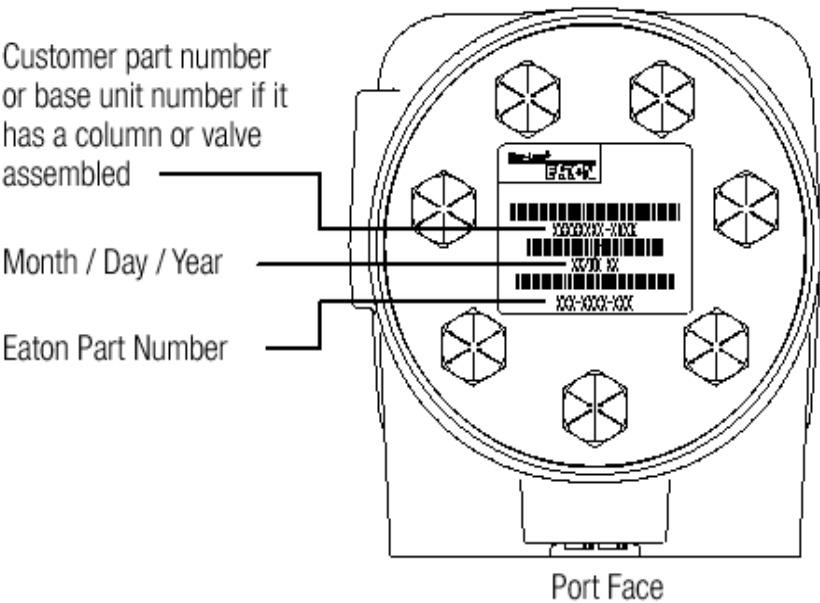


Figure 5

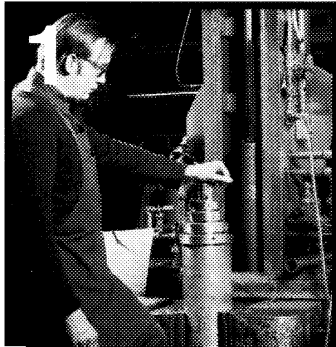
Manual Input Torque Limits

Displacement cm ³ /r [in ³ /r]	Displ. Code	Maximum Input Torque Nm [lb-in]
60 [3.6]	40	3,4 [30]
75 [4.5]	43	3,4 [30]
95 [5.9]	45	3,4 [30]
120 [7.3]	48	3,4 [30]
146 [8.9]	50	3,9 [35]
159 [9.7]	51	3,9 [35]
185 [11.3]	52	4,5 [40]
231 [14.1]	54	5,1 [45]
293 [17.9]	57	5,6 [50]
370 [22.6]	59	7,9 [70]
462 [28.2]	61	9,0 [80]

Figure 6



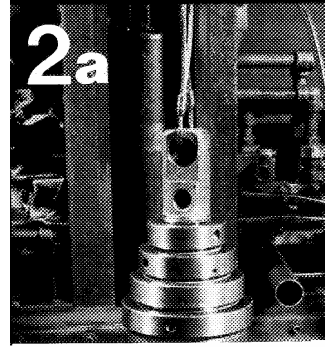
Cylinder Disassembly



1
Secure the cylinder with the rod end up to a sturdy work bench or a suitable stand that has access to an overhead crane.



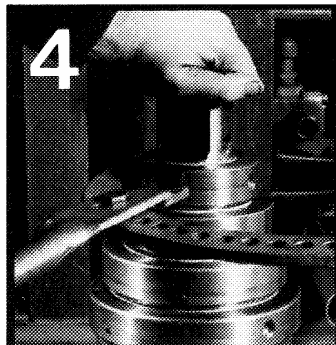
2
Remove air release valve with a $\frac{1}{2}$ " open end wrench or an adjustable crescent wrench.



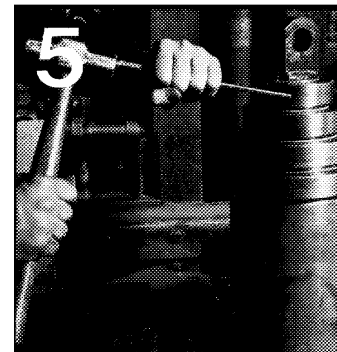
2a
Remove pipe plugs on double-acting telescopes with an adjustable crescent wrench.



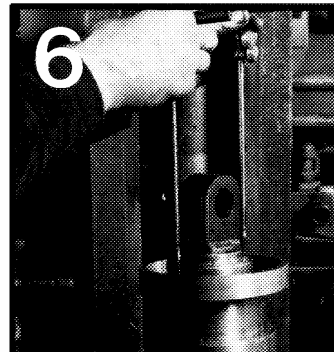
3
Remove set screws from all packing nuts with a $\frac{1}{8}$ " Allen wrench.



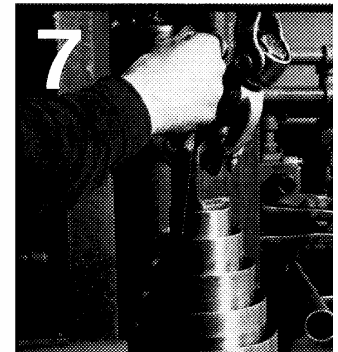
4
Remove all packing nuts with adjustable spanner wrench, G3067-84K-4, starting with the smallest thru the largest.



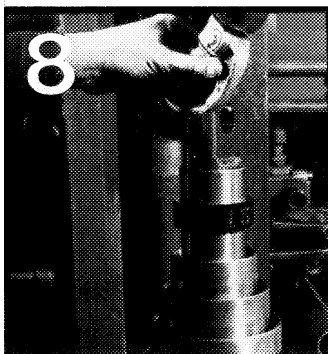
5
If the nut will not move, a sharp rap with blunt chisel or rod may be required to jar the nut loose.



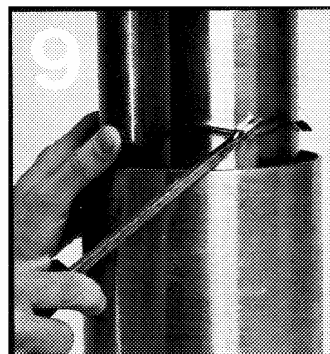
6
Remove all bearing rings with two bearing ring pullers M3067-4.



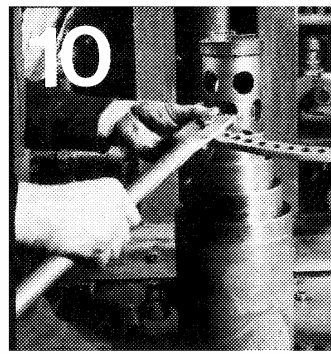
7
Remove all packings with packing puller V3067-1 or use a dull knife as shown above and lift sleeve or plunger with crane.



8
Packing will usually pop out as shown, if not, repeat the process of wedging and lifting.

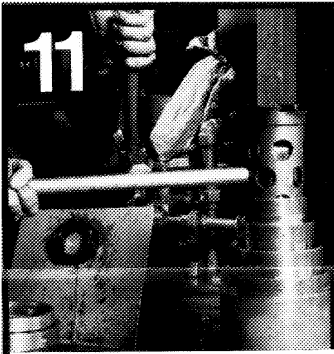


9
Remove wave spring from packing recess with a narrow screwdriver.

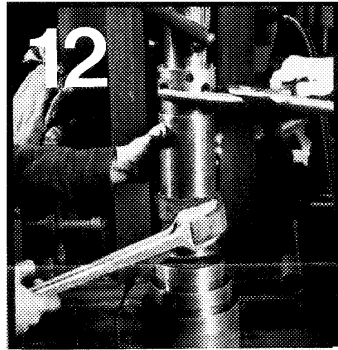


10
Remove stop rings from all stages with stop ring wrenches BA3067 series.

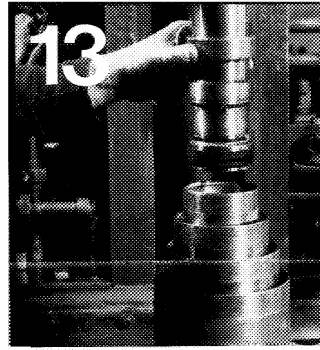
Cylinder Disassembly



If the stop ring will not move, a sharp rap may be required to jar the ring loose.



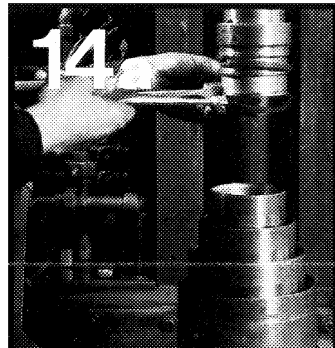
If the sleeve containing the stop ring turns during removal, it should be held with a nylon strap wrench P3067.



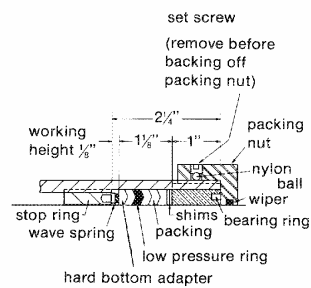
Removal of the plunger or sleeve will lift out the stop ring and expose the piston bearing ring. Use lifting ring tool series BC3067 to lift out the sleeves.



Remove piston bearing ring by hand.



Remove piston rings on double-acting cylinders with piston ring plier M3067-3K and remove piston bearing ring or rings by hand.



HEADNUT ADJUSTMENT PROCEDURE ON TELESCOPIC CYLINDERS

1. Make sure that all hydraulic pressure is relieved in the cylinder before attempting to adjust the headnuts.
2. Loosen up or completely remove the set screws from all the headnuts.
3. Before adjusting the headnuts, use a hammer to lightly tap the circumference of each headnut.
4. Use a chain wrench to tighten each of the headnuts, being careful not to let the wrench go across the loosened set screw or screw bores. Start with the body headnut and tighten it as tight as possible. DO NOT use a cheater bar. Next, move on to the first stage headnut and tighten it until the headnut and first stage move as one. Move on to the second stage and tighten the headnut until the second stage starts moving with the headnut. Keep moving up and tighten each stage in order, from the largest to the smallest.
5. Re-install and/or tighten up the set screws in each of the headnuts until the set screw bottoms out in the bore. DO NOT OVERTIGHTEN. Overtightening can distort the tube underneath the headnut.
6. Also, be sure that the bleeder valve is tight in its bore.

WARNING

BEFORE MAKING ADJUSTMENTS OR REPAIRS TO THE CYLINDER WHEN MOUNTED IN THE UNIT, USE STRONG, HEAVY, POSITIVE SUPPORTS TO HOLD THE BODY FROM ACCIDENTALLY LOWERING WHICH CAN CAUSE SEVERE INJURY OR DEATH AND/OR DAMAGE TO THE UNIT AND CYLINDER. PLACE CONTROL VALVE IN THE LOWER POSITION TO INSURE THE PRESSURE IS RELIEVED IN THE CYLINDER. HIGH PRESSURE CAN CAUSE SEVERE INJURY OR DEATH AND/OR DAMAGE TO THE UNIT AND CYLINDER.

Bleeding Air from Single-Acting Telescopic Cylinders.

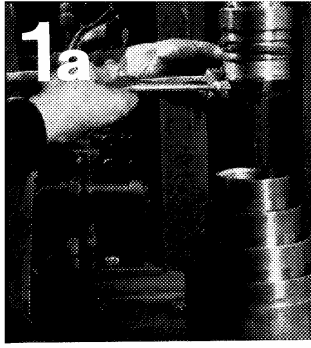
For smooth operation of these cylinders, it is advisable to bleed the air from the cylinder weekly. Manual bleeding is accomplished by:

1. Fully lower the carriage with no load on the forks.
2. The bleeder valve is located directly on top of the lift cylinder rod.
3. Fully extend the cylinder, raising the carriage.
4. Lower the carriage to within 1 foot from resting on the floor.
5. With the fingers turn the bleeder valve in a counterclockwise direction.
This opens the valve and allows the air to escape from the cylinder.
6. When a steady stream of oil comes from the bleeder, turn the valve in a clockwise direction until it is closed.

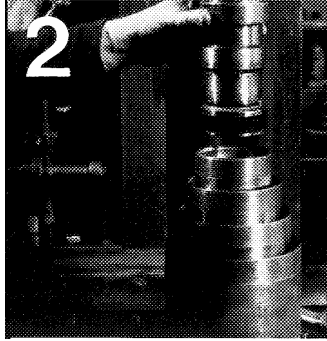
Cylinder Assembly



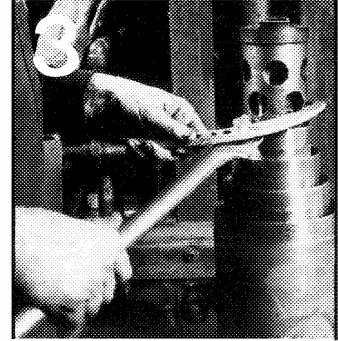
Assemble piston bearings to all sleeves and plunger by hand.



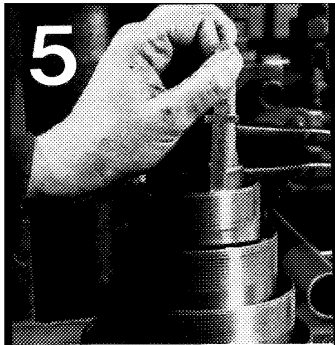
Assemble piston rings on double-acting cylinders using piston ring pliers M3067-3K. Install piston bearing ring or rings by hand.



Slide stop rings onto the plunger and all sleeves and lower into the assembly. Use lifting tool series BC3067 to handle the sleeves.



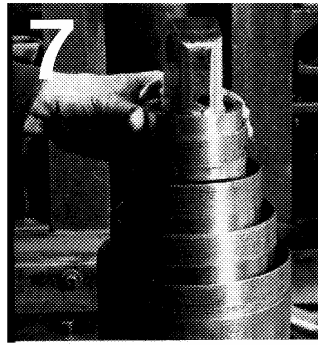
Assemble all stop rings with stop ring wrench series BA 3067. Bottom out with a sharp rap.



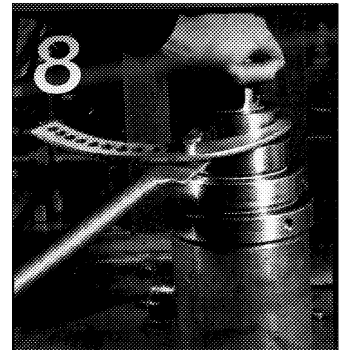
Measure stop ring depth.



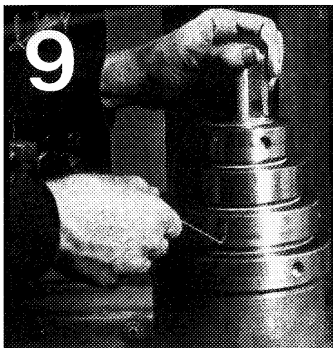
Measure packing height and follow packing assembly instructions. *



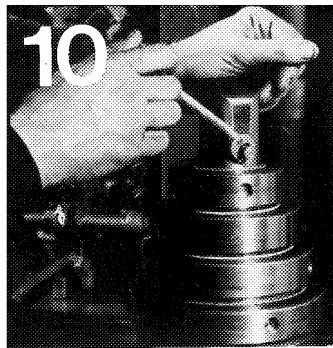
Install all bearing rings with tapped holes showing.



Assemble all packing nuts starting with the largest and tighten with the adjustable spanner wrench G3067-84K-4.



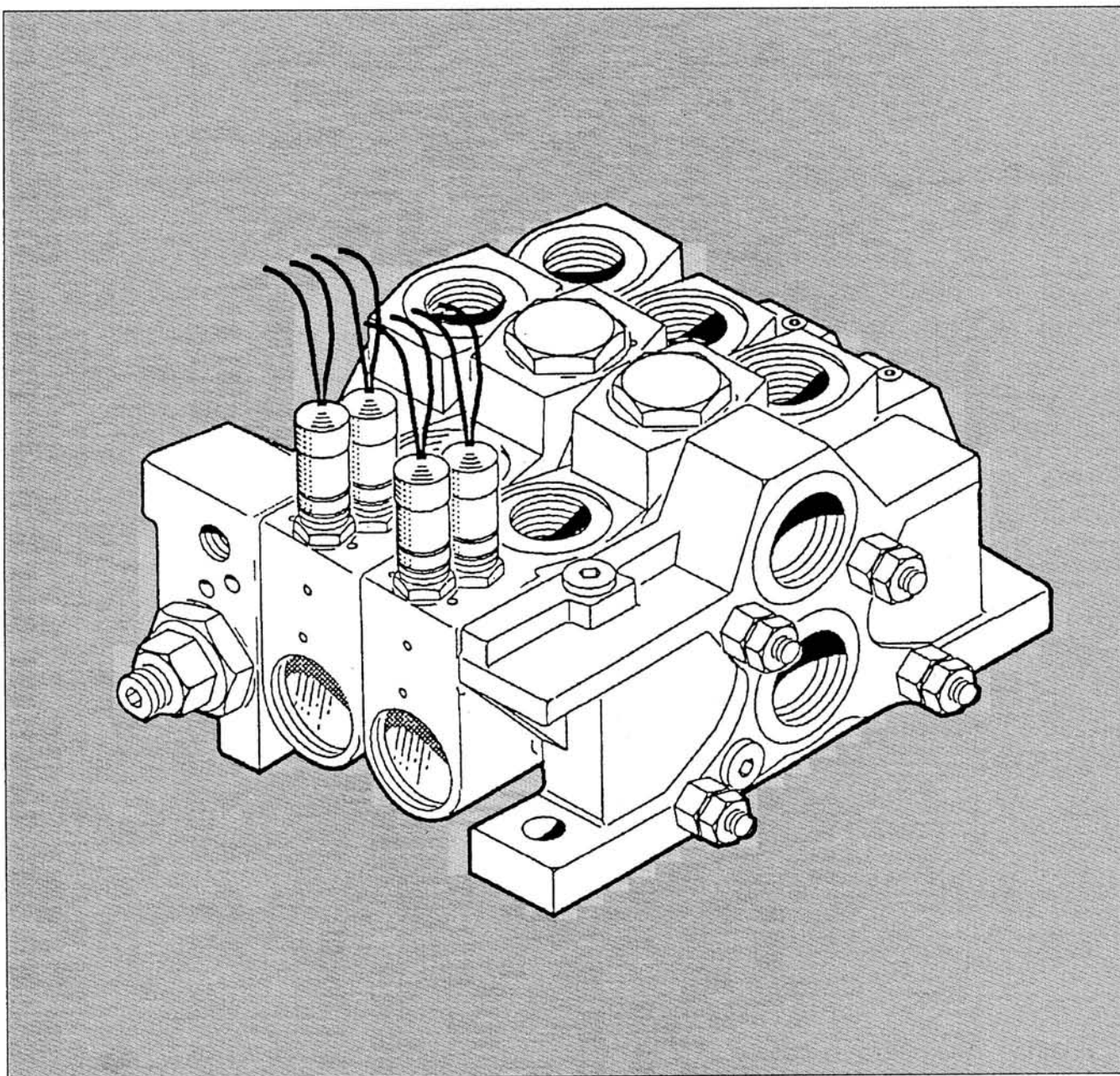
Install nylon balls and set screws into all packing nuts and tighten with $\frac{1}{8}$ " Allen wrench.



Install air release or pipe plugs as applicable.

VP/VPO PROPORTIONAL VALVE

Assembly and Adjustment Instructions



Introduction

"Pulsar™ VP/VPO Series Valve Assembly and Adjustment Instructions" is furnished to assist in the process of taking this product line from the shelf to the customer. Primarily, this process consists of stacking the valve, installing the selected options and making final adjustments. Ample page margin is provided for related notes.

Fluid Power Systems recommends performing these procedures in the order presented. Assembly drawings for the VP/VPO Series working segments and the VB Series pressure compensated inlet are included for reference.

VALVE STACK ASSEMBLY	1
SEGMENT ALTERATIONS	5
Spool Replacement	5
Pulsar Replacement	7
Solenoid Removal and Plug	7
RECOMMENDED TEST STAND	9
Specifications	9
Configuration (Figure 1)	10
Valve Spool Connections (Figure 2)	11
FINAL STACK ADJUSTMENT	12
Bypass Inlet With Relief	12
Pilot Pressure	13
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Flow Limiter	19
Pressure Limiter	20
Work Port Relief	21
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ASSEMBLY DRAWINGS	23
VP Working Segment	23
VPO Working Segment	24
VB Bypass Inlet Segment	25
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As in any assembly procedure, it is beneficial to anticipate the final needs of the included segments and valve stack to avoid unnecessary steps.

Additional useful assembly tools/supplies:

- O-ring pick
- pencil magnet
- 10-inch (25 cm) plastic rod
- snap-ring tool
- torque wrench, 100 foot-pounds (135 Nm)
- manual override subassembly, VPH6K1
- clean, light-weight hydraulic oil

VALVE STACK ASSEMBLY

General

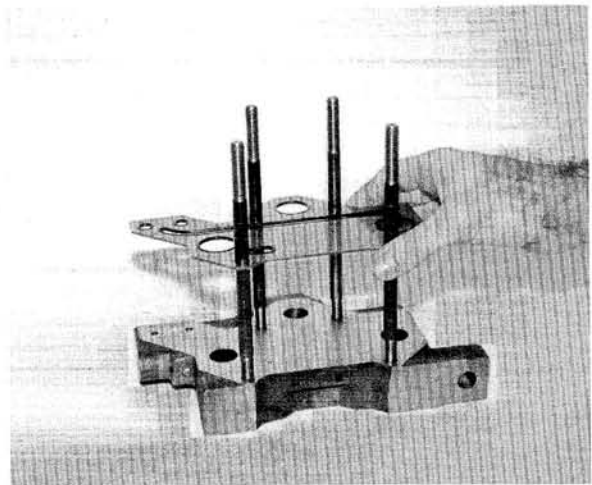
1. Assembly of a VP/VPO Series valve stack requires the following parts or kits:
 - one (1) inlet segment
 - one (1) stacking plate
 - correct number of working segments and accompanying spool kits
 - assembly kit for the appropriate number of segments
2. Have on hand:
 - clean, flat work area
 - one (1) manual override handle sub-assembly (VPH6K1)
 - clean, light-weight hydraulic oil
 - 100 ft-lb (135 Nm) torque wrench

Assembly Procedure

Inlet

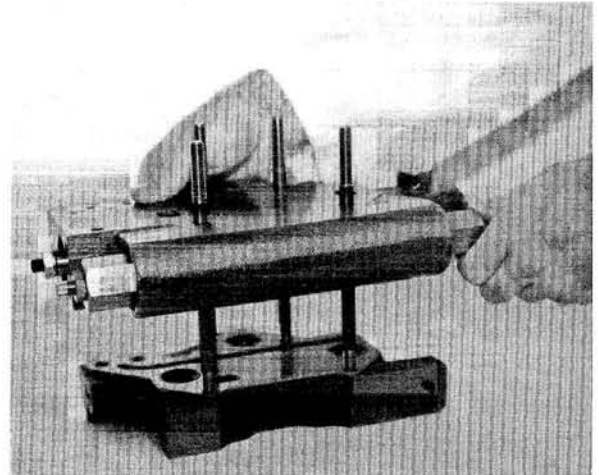
1. Lay the inlet down to install tie rods vertically into the section. Hand tighten until each bottoms out in the threaded hole.
2. Open one seal plate kit and verify the included parts: one (1) shuttle ball and one (1) seal plate.
3. Be sure the surface of the inlet section and seal plate are clean and free of any foreign material. Place the seal plate over tie rods and onto the inlet.

IMPORTANT!! Do not install shuttle ball between the inlet and first working segment!



Working Segment

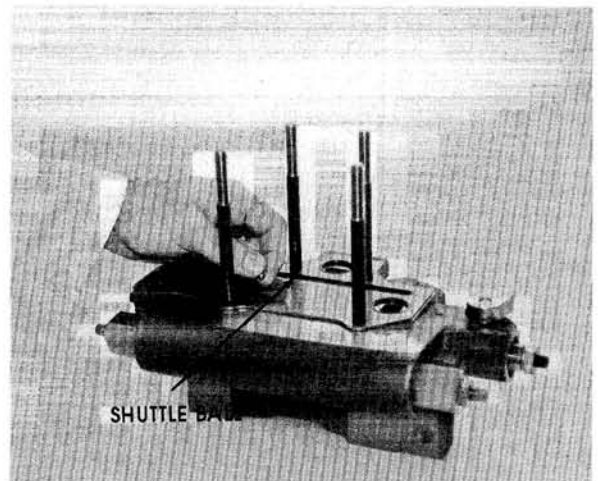
4. Prepare for installation of working segments by verifying all mating surfaces are clean and free of foreign material. Slide the segment over the tie rods taking care not to allow the tie rods to damage the surface of the segment. Open the next seal plate kit and again inspect for correct parts. Install as in previous Step 3.



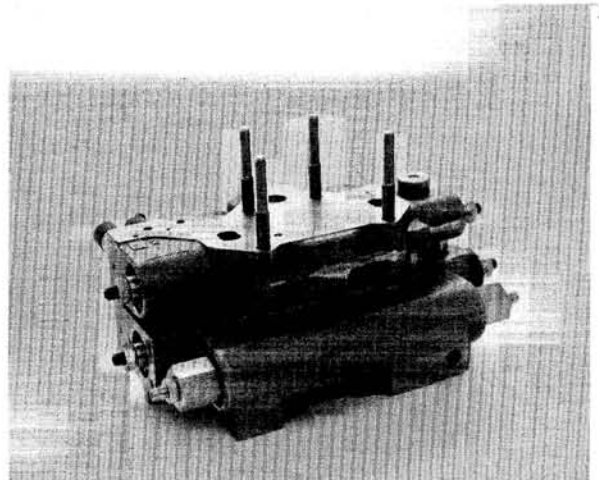
IMPORTANT!! Shuttle ball is installed if:
Another work segment is NEXT to be installed,

-OR-

the stacking plate section to follow is machined with a load sensing seat and sensing port for use with downstream load sensing logic.*



5. Repeat Steps 3 and 4 for additional spool sections.



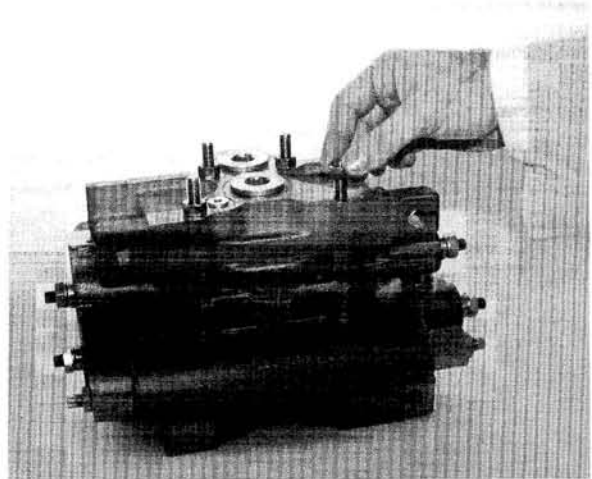
Shuttle balls ARE installed **between all working segments, OR between the last working segment and stacking plate **only** if load sensing is to be relayed from downstream valves.*

Stacking Plate

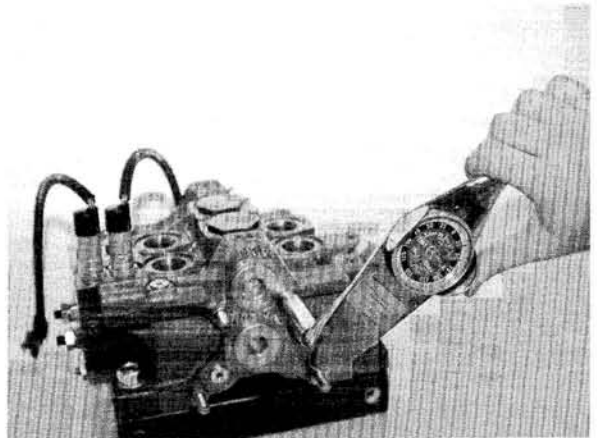
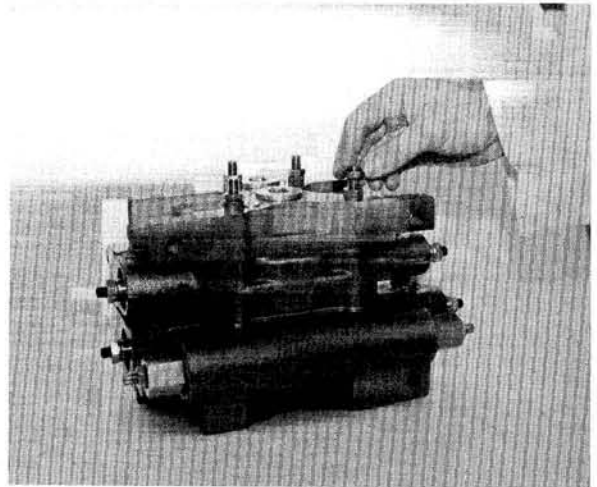
6. Carefully install the stacking plate segment.



7. Install the four (4) large nuts from the tie rod kit onto tie rods and hand tighten. Carefully lay the valve onto the mounting pads. Tighten the nuts to 15-20 ft-lbs. (20-27 Nm) torque using a crossing pattern in 2-1/2 ft-lb. (3.4 Nm) increments.

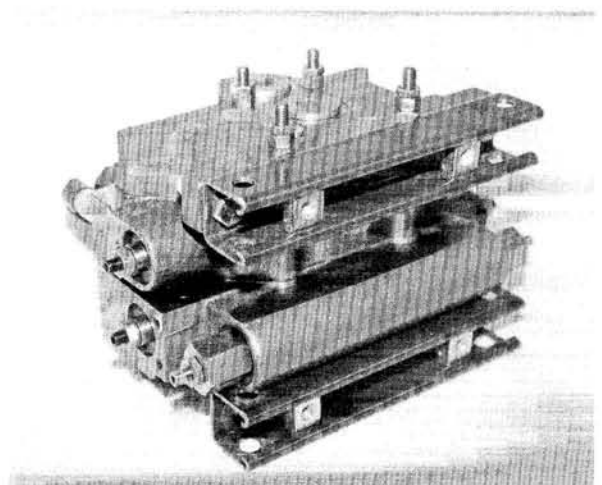


8. Install all four (4) small nuts onto tie rods and tighten to 15-20 (20-27 Nm) ft-lbs. torque using any pattern.



9. Install manual handle and shift each spool. Check that each spool operates freely to full "on" in both directions and returns to neutral with spring force only.

Note: Stacks that include the VPO style body may utilize the VPO Mounting Spacer kit, No. VPOMK1, to accommodate this taller segment.



SEGMENT ALTERATIONS

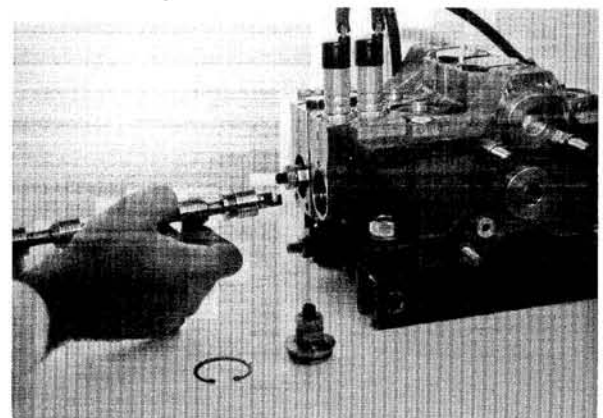
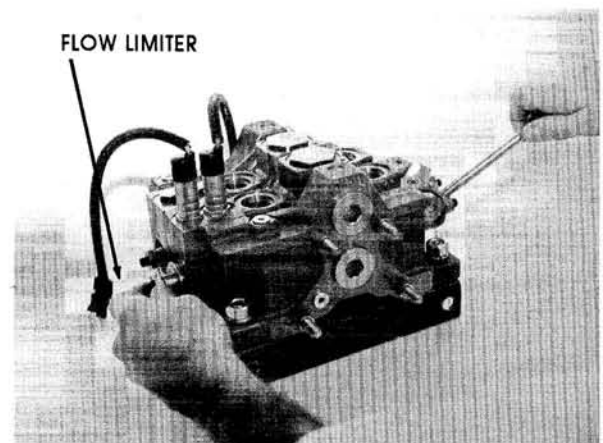
VP/VPO Series Spool Replacement

General

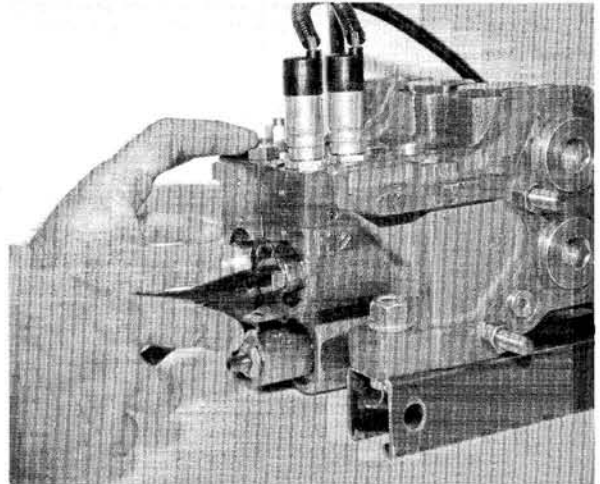
In the VP/VPO Series valve, the main spool may be one of two types: proportional or "on/off." The main spool determines the segment type. Therefore, to change flow rates, or to change from proportional to "on/off" operation, it is the main spool which is exchanged. Also, please note that VP Series spools are of a different length than VPO spools and cannot be exchanged between segment bodies.

Spool Replacement Procedure

1. Install a manual override handle. Using a snap ring tool, remove the flow limiter assembly opposite the manual handle side. Rotate the override handle away from the valve until the assembly pops out. Insert a finger or hooked tool into the spring guide and pull the spool assembly out. Use care to pull the spool out as straight as possible, as side forces may damage the spool and/or bore.
2. Unpack the new spool assembly. Check that the spool is marked with the same number as shown on the packing. (Example: VP824K1 on the packing should show #824 on the spool.) Using a hard Arkansas stone, lightly "stone" the spool surface to remove minor nicks and burrs.
3. Make sure the new spool assembly is clean and free of any foreign material. Coat the spool with a thin layer of clean hydraulic oil. With the valve stack resting on the mounting pads, rotate the override handle fully downward, i.e., away from the valve. Carefully slide the spool straight into the bore with spool linkage groove facing upward. Again, exercise caution regarding placing a side load on the spool. Slide the spool in until it contacts the override linkage, then rotate the handle upward, thus pulling the spool the rest of the way into the bore. By slightly rotating the manual override back and forth, it is possible to check for proper installation.



4. Reinstall the flow limiter and push into position. Install the snap ring and check that it has seated completely. Use the manual override handle to fully shift the spool in both directions. Spool movement should be free of binding and capable of returning with spring force only. Check that flow limiters are securely seated.
5. With an "X" stamp, cross out the VP/VPO number that appears on the valve body above the pipe plug next to the override handle.
- 6a. For spool replacements involving flow rates less than 28 GPM (106 L/min), remove the stamped compensator plug and replace it with a new blank cap. Make sure no foreign material falls into the compensator. Stamp the new information on the cap, such as "10 GPM CC (38 L/min)" See **page 14 for compensator adjustment procedure.**
- 6b. Replacements that involve changing to spools of 28 GPM (106 L/min) or greater, also require changing to the high profile compensator design. See **page 17** for this procedure.



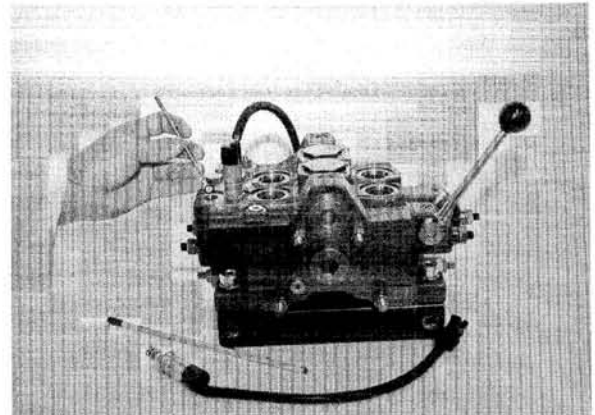
Pulsar™ Solenoid Replacement

General

All individual Pulsar™ solenoids available as service parts provide proportional control for the main spool. Should it be necessary to replace a solenoid, it will be necessary to identify which version(s) are involved. Prior to June 1992 all Pulsars™ were accompanied by their own separate orifice disk. After June 1992, the orifice is pressed in and integral to the lower body nozzle. As of November 1, 1996, a new filter design was implemented which also secures the lower O-ring to the lower body nozzle.

Replacement Procedure

1. Remove the used solenoid (Item 23) and examine the nozzle end for the presence of a pressed in brass orifice plug.
- 2a. If the assembly includes the brass insert, without the O-ring secured to the lower body, simply remove the remaining O-ring from the segment cavity. Refer to Product Advisory 25 for further information.
- 2b. If the assembly includes the brass insert, with the lower O-ring secured to the lower body, simply remove complete solenoid. Refer to Product Update 046.
- 2c. If the assembly does not include the brass insert, remove the O-ring and, using a clean pencil magnet, also remove the orifice disk from the bottom of the Pulsar™ cavity.
3. With this removal now complete, install the new O-ring if applicable and check for proper seating.
4. Screw in the new solenoid with integral orifice and torque to 6.5 ft-lbs (9 Nm).
5. Any failed Pulsar™ solenoid should be returned to Fluid Power Systems for evaluation. Securely bag the cartridge assembly and orifice disk as required. If possible, allow the connector wires to remain outside the bag, as they may introduce contamination. Then contact your Fluid Power Systems representative for further return information.



Pulsar™ Solenoid Removal and Plug

General

For applications using 2-position spools, only one Pulsar™ solenoid is needed. Unless otherwise specified, VP/VPO Series valves direct flow to the C₁ cylinder port. In these cases, the unused solenoid can either remain disconnected in the valve segment as a spare, or can be removed and plugged. Removed Pulsars must be replaced with the correct plug, as the cavity is not that of a standard fitting.

Procedure

1. Remove the existing C₂ solenoid cartridge. For standard VP/VPO segments, this is the Pulsar™ closest to the manual override, but for high response segments, remove the other solenoid.
2. Inspect the nozzle end for the presence of a pressed in brass orifice plug.
- 3a. If the removed Pulsar™ includes the brass insert orifice plug, then simply remove the remaining O-ring from the segment cavity.
- 3b. If the Pulsar™ does not have the brass insert, then remove both the O-ring and, using a clean pencil magnet, also remove the orifice disk from the bottom of the valve cavity.
4. Unpack the solenoid plug kit, VNPK1, and verify the contents: two (2) solenoid plugs, four (4) O-rings.
5. Install the solenoid plug (Items 19, 20, 21) using 5-10 ft-lbs (7-14 Nm) torque.

RECOMMENDED TEST STAND

Specifications

Hydraulic Oil — Fluid Power Systems recommends petroleum-based hydraulic oil having 150 SUS viscosity at 100° F (38°C).

Filtration Level — 10 micron, high pressure, non-bypass.

Temperature Range — Test to be conducted from 100°F to 120°F (38°C - 49°C).

Pressure Range & Measurement — Test stand pump, controls and plumbing capable of producing and withstanding pressures from 100 psi to 3,500 psi (6.8 bar - 245 bar).

Flow Range — Test stand fixed displacement pump (with bypass inlet included), controls and plumbing to produce and accommodate flow up to the required flow rate.

Flow Measurement — Flow meter capable of measuring the required flow rate with acceptable accuracy.

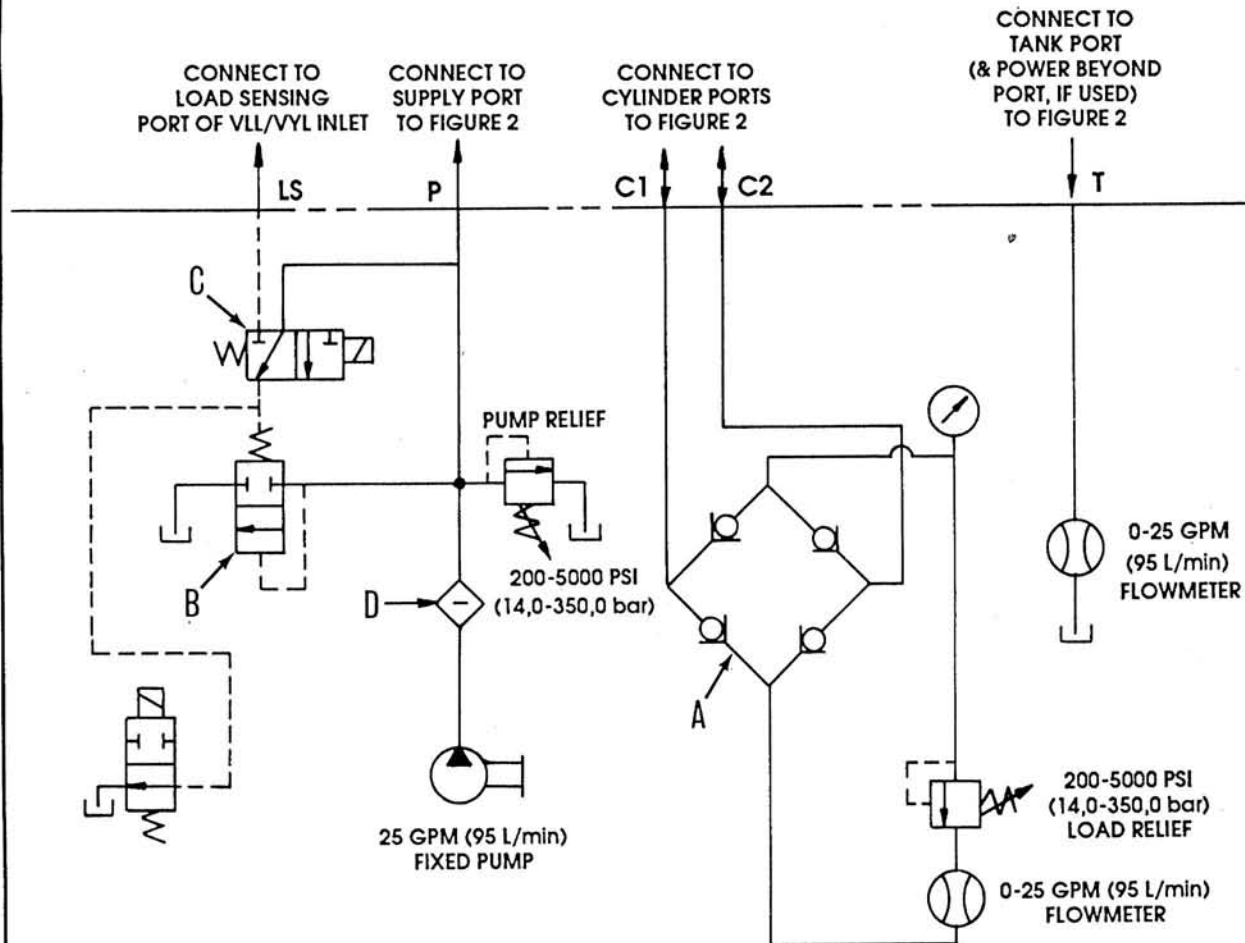
Electrical Solenoid Control —

- Power supply of 12 VDC and 24 VDC, with negative voltage spike suppression from -10 to -20 VDC for 12 VDC. For 24 VDC (-20 to -36 VDC).
- Pulse-width modulated frequency output of 33 Hz.
- Recommend using Fluid Power Systems 12 VDC MC3100-0036 power module or 24 VDC MC3200111 power module.

Configuration

The test stand arrangement shown (FIGURE 1 and 2) is suggested. Fluid Power Systems recognizes the variety in test facilities of its distributorships. Consequently, it is expected each distributorship will configure a suitable test facility to satisfy requirements of both product qualification and individual needs.

SUGGESTED TEST STAND CONFIGURATION



NOTES

- A OPTION TO USE PRE-PACKAGE CIRCUIT SAVER FROM SUN HYDRAULICS, P/N CXHA XCN YSG.
- B VB-2211-5001 AND V0-0011-0001
- C USE LEFT CONFIGURATION FOR TESTING VB INLET STACK, USE RIGHT FOR VL INLET STACK.
- D 10 MICRON, NON-BYPASS FILTER.

FIGURE 1

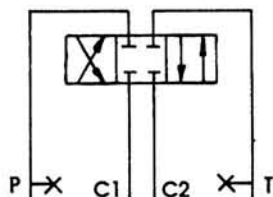
SECTION VALVE SPOOL
CONNECTIONS TO TEST STAND
(SHOWN IN FIGURE 1)

2 POSITION, 4-WAY

$P \rightarrow C1$

3 POSITION, 4-WAY

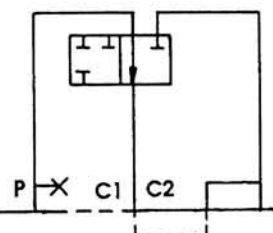
$P \rightarrow C1/P \rightarrow C2$



TEST STAND
FROM FIGURE 1

2 POSITION, 2-WAY

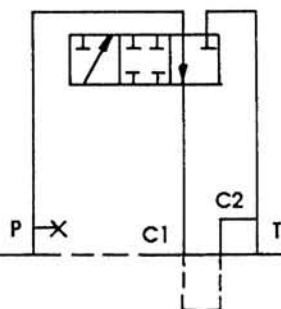
$P \rightarrow C1$



TEST STAND
FROM FIGURE 1

3 POSITION, 3-WAY

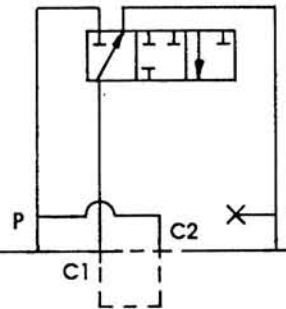
$P \rightarrow C1$



TEST STAND
FROM FIGURE 1

3 POSITION, 3-WAY

$C1 \rightarrow T$



TEST STAND
FROM FIGURE 1

FIGURE 2

FINAL STACK ADJUSTMENTS

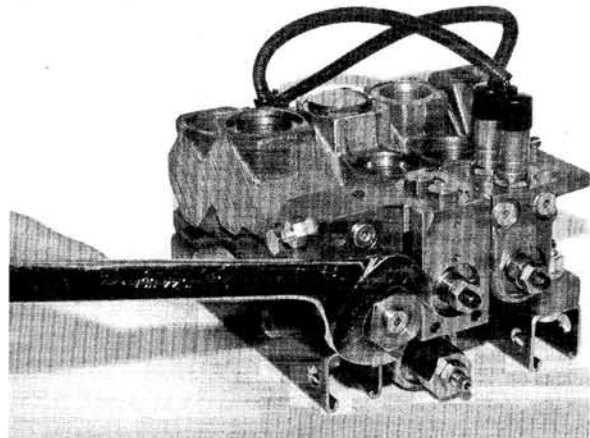
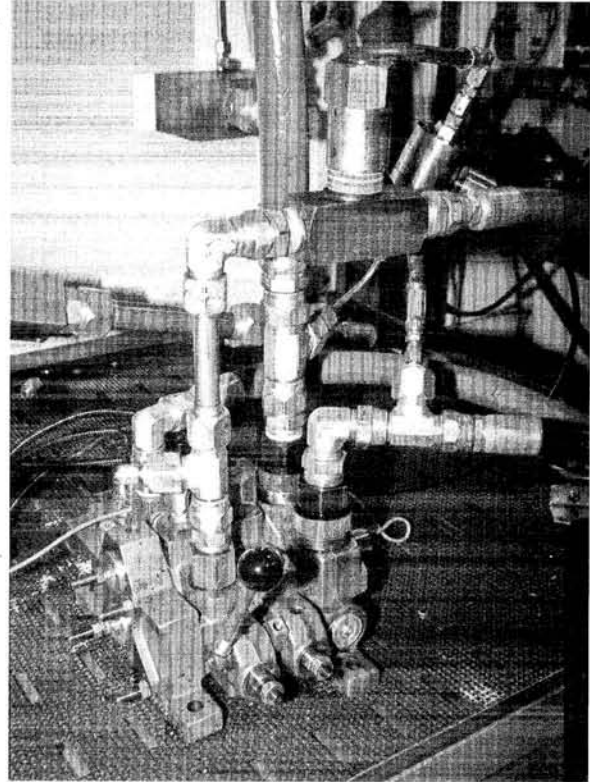
Bypassing Inlet With Relief Inlet Adjustment

General

The pressure compensating bypass inlet (VB) requires two (2) adjustments. One adjustment establishes maximum working pressure and ensures the availability of a minimum pilot supply pressure of 200 psi (14 bar), the other sets the internal relief valve pressure.

Bypass Compensator Adjustment Procedure, VB2211-****1

1. With the valve stack connected to supply pressure and tank return line, insert a pressure gauge in each line. Also, insert an in-line flow meter in the return line. Load circuit connection is not required for this adjustment.
2. Turn the test stand "on" and adjust the pump relief valve such that maximum bypass pressure is achieved, i.e., when no further increase in supply pressure occurs.
3. Adjust the pump flow setting to deliver the minimum/idle flow specified for this application, or use 10 GPM (38 L/min) if this number is unknown.
4. Turn out the bypass adjustment plug (Item 20) until the pressure difference between the gauges is 200-210 psi (13,8-14,5 bar). While holding this adjusted position, tighten the lock nut (Item 16) with a torque of 60-70 Ft-lbs. (81-95 Nm)

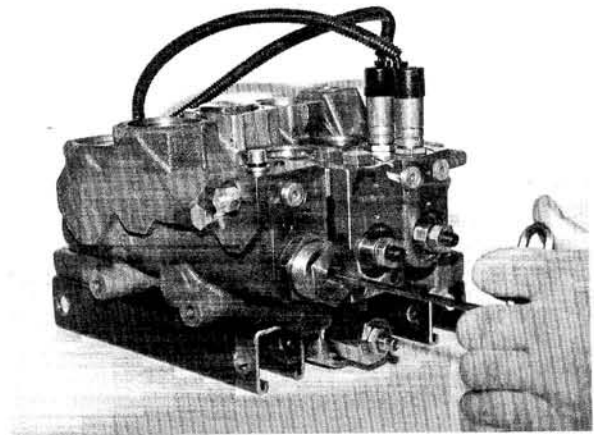


Inlet Relief Valve Adjustment Procedure

5. With the test stand pump "on," be sure the pump or system relief setting exceeds the specified system relief setting by 200 psi (14 bar). Remove the SAE plug (Item 27) to adjust the socket set screw (Item 37) until the supply pressure does not exceed the specified relief pressure setting. The adjustment of this set screw is stiff and is equivalent to 1,000 psi (70 bar) per 360° turn. The maximum relief adjustment is 3,500 psi (241 bar) and should at no time be exceeded.

Substitute the following items for (4) above if adjusting VB2213-***1

- 4a. Be sure the neutral loading set screw (Item 18) is fully backed out as to be unable to affect the P_s to P_t reading.
- 4b. With all main spools centered, adjust the bypass pressure adjustment plug (Item 17) to between 180-190 PSID (12-13 bar above tank pressure) While maintaining the adjusted position, tighten the lock nut (Item 16).
- 4c. Again with spools centered, adjust the neutral loading set screw (Item 18) to 205-210 PSID (14-14,5 bar above tank pressure) and tighten the associated lock nut (Item 19).



Pilot Pressure Adjustment

General

Pilot operated working segments are supplied the appropriate pressure via a pilot reducing valve located in the inlet. The pilot pressure required by a particular segment varies somewhat according to maximum flow rate or pilot type.

As of 6/92, Pulsar™ Series valves are outfitted with an externally adjustable pilot reducing valve, thereby eliminating the need for different thicknesses of shims. This permits the exact setting to be made that is required to achieve full stroke on the working valve segment. These new parts are retrofittable to existing castings and therefore may be used as a replacement on previous inventory.

Pilot Reducing Adjustment

The accompanying photo shows the reducing valve assembly as it is installed in a VL Series inlet. With the locking nut loosened, pilot pressure can be adjusted according to the following guidelines:

Nominal Adjustment Limits

VP/VPO Series

215-225 psi < 20 GPM (15-16 bar < 75,7 L/min)

230-240 psi > 20 GPM (16-17 bar > 75,7 L/min)

VW Series

350-355 psi (24-25 bar)

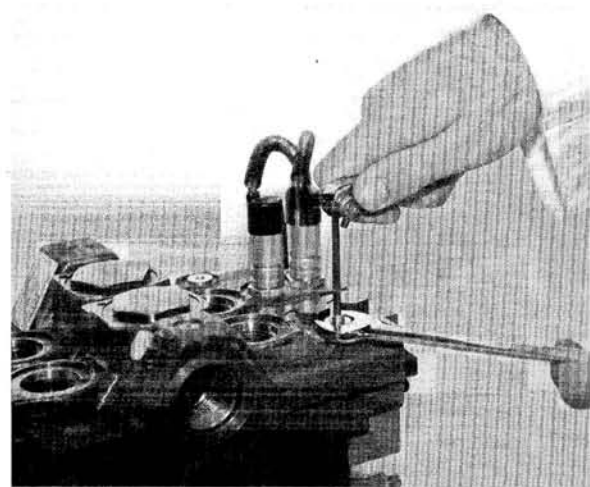
Nominal Adjustment Sensitivity

VP/VPO Series

40 psi per turn (2,8 bar)

VW Series

75 psi per turn (5,3 bar)



CAUTION: WHEN ADJUSTING THE PILOT VALVE, THERE IS NOT A PHYSICAL STOP WHEN TURNING THE SCREW OUT. CAUTION MUST BE USED IN THIS PROCEDURE TO MAKE SURE THE PRESSURE LIMITS ARE NOT EXCEEDED.

Individual Segment Compensator Adjustment

It is advisable to review this entire procedure prior to adjustment.

General

Proportional VP and VPO working segments include any of 9 spools with "rated flows" from 2.5 GPM (9,5 L/min) to 40 GPM (151 L/min). The individual segment compensators of packaged segments are factory set to provide those rated flows. However, for applications that require a flow rate between the available spool ratings, such as 25 GPM (95 L/min), the segment compensator may be adjusted to provide the required flow range.

VQ or VQO ON/OFF segments use a square-shouldered spool. Standardly these segments are factory set using the individual compensator and flow limiters to deliver between 22 and 26 GPM (83-99 L/min). As this arrangement is substantially different from proportional VN(O), VW(O) AND VP(O) segments, they will be discussed separately.

Test Stand Preparation

With the valve stack connected to supply pressure and tank, connect the load circuit and flow meter to the segment cylinder ports. Two-way or 3-way segments require a return line back to tank.

Turn the test stand "On" such that pump flow passes over the pump relief valve at 1,700 PSI (117 bar). For valve stacks with VB inlets, bottom out the full flow adjustment (Item 20) to prevent bypassing.

Energize the solenoid with 100 percent modulation ratio (M.R.) to produce load flow through the cylinder port. Set the load circuit relief valve to 1,500 PSI (103 bar). Recheck the supply pressure and "tune" both relief valves until the supply pressure is approximately 1,700 PSI (117 bar) and load pressure about 1,500 PSI (103 bar).

Note: Refer to Product Advisory No. 013 for descriptions of the various compensator configurations. Options B,C,D, and E are no longer available on new segments.

Compensator Adjustment, Spools 1-7

Each of these spools use the standard low profile compensator and are shim adjustable. Available shim thicknesses (Kit No. VPCSK1) are as follows:

P/N DB1044.248 = 0.025 inches (0,635mm)

P/N DB1045.248 = 0.008 inches (0,203mm)

P/N DB1046.248 = 0.003 inches (0,076mm)

There should never be more than two (2) pieces of either 0.008" (0,203 mm) or 0.003" (0,076 mm) stock for any setting. Also, the thinnest shims 0.003" (0,076 mm) should be placed at the bottom of the shim stack.

About the Compensator Shim Adjustment Graph

- Figure 3 shows the relationship between "DELIVERED FLOW" through a segment compared to the "ADDED SHIM THICKNESS" required to increase the flow above its rating. These curves provide only approximate thickness adjustments and require testing to confirm the flow.
- As previously noted, each segment is factory set. Therefore, the existing shim condition in a proportional segment is that which provides rated flow.

- The spool number, 1 through 9, is found in the first numerical position of the VP or VPO Series model number, i.e., VP5***-**** is Spool 5 whose rated flow is 10 GPM (38 L/min). In the graph, nine proportional spools are shown with ratings from 2.5 to 40 GPM (10 to 152 L/min). Rated flow for each is found where the spool curve meets the left vertical axis. (See arrows.)
- Each spool should **ONLY** be used within its designed metering range. Spool 3 is for 5 GPM (19 L/min) to 7.0 GPM (26 L/min). Therefore:
 - a. To increase the flow of a single spool within its eligible range, simply add the appropriate amount of shim material to the compensator. This moves the maximum available flow from left to right along the shim curve.
 - b. To substantially change the flow from a segment, as required when changing from one spool to another, first exchange the spool, then adjust the segment compensator as necessary. For example, when changing a 7 GPM (27 L/min) segment to provide 18 GPM (68 L/min), first exchange the No. 4 spool to a No. 6, then adjust the compensator shimming accordingly.

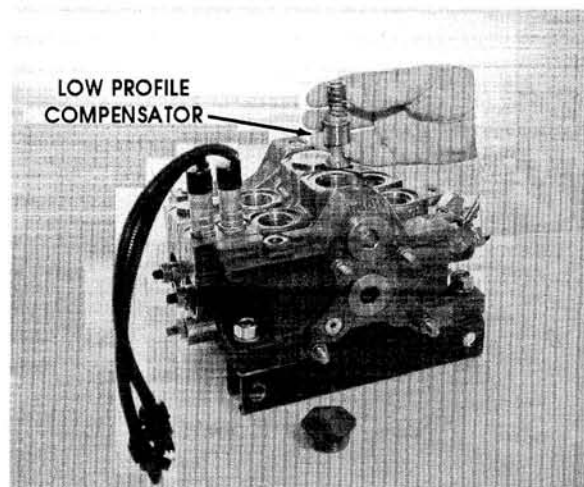


TABLE 1
FLOW RANGE OF MAIN SPOOLS

Spool I.D. No.	Rated Flow GPM (L/min)	Flow Range GPM (L/min.)
9 *	40 (152)	40-55 (152-208)
8 *	28 (106)	28-40 (106-152)
7	20 (76)	20-28 (76-106)
6	14 (53)	14.0-20 (53-76)
5	10 (38)	10.0-14.0 (38-53)
4	7 (26)	7.0-10.0 (27-38)
3	5 (19)	5.0-7.0 (19-27)
2	3.5 (13)	3.5-5.0 (13-19)
1	2.5 (9.5)	2.5-3.5 (9-13)

* Requires high profile individual compensator.

Adjustable Compensator Option

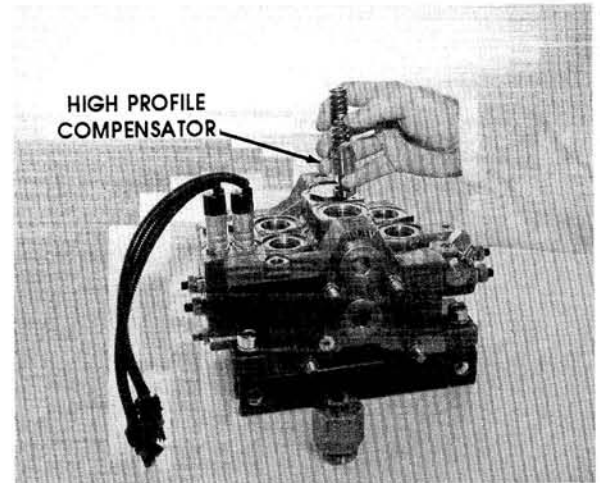
This option uses the high profile design which includes a longer spring and taller compensator cap. This version is externally adjustable within the designed metering range for each spool but up to 60 GPM (227 L/min) with No. 9 spool.

When changing from a low profile to a high profile, the compensator cap (Item 26) requires 80 to 85 ft-lbs (108-115 Nm) of torque, while the adjustment lock nut is tightened to 5-10 ft-lbs (7-14 Nm).

Compensator Adjustment, VQ and VQO Spools

Unless otherwise specified, these spool segments are factory set to provide 22 to 26 GPM (83 to 99 L/min). Therefore:

1. To achieve flow rates below the factory setting, turn in the appropriate flow limiter(s) to desired flow rate.
2. For flow rates above the factory setting, back out the flow limiters until the desired flow is achieved. Or, if flow limiters are no longer positioned to short-stroke the spool, then add shim stock according to the Flow Setting Graph (Figure 3) to increase flow through the segment up to 40 GPM (152 L/min) max., and adjust flow limiters as needed.



DUAL SPRING INDIVIDUAL COMPENSATOR SHIM ADJUSTMENT

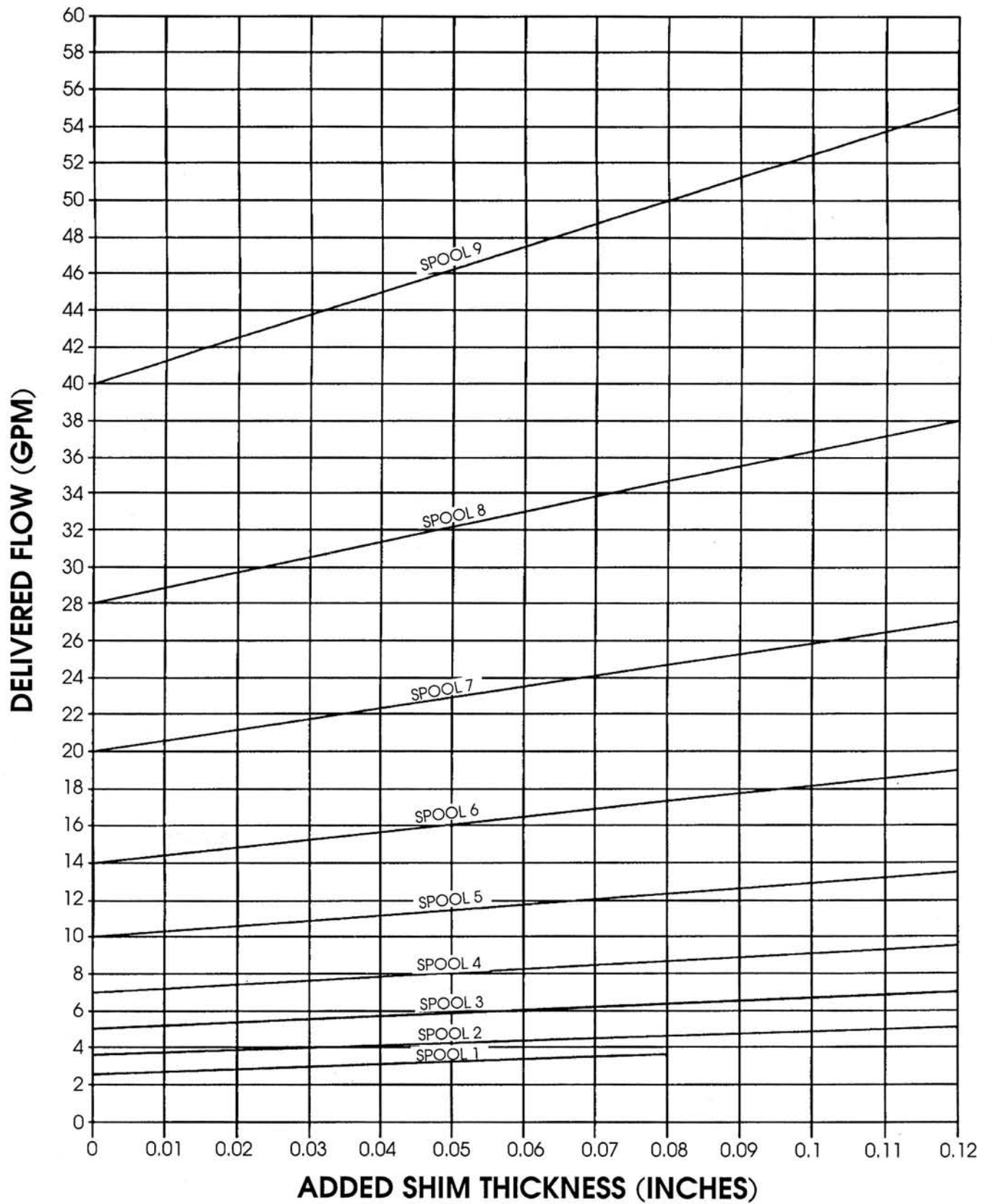


FIGURE 3

Flow Limiter Adjustment

General

Adjustment of the spool flow limiter is appropriate:

1. In all on/off (VQ) segments.
2. In 4-way VP proportional segments if a lower flow rate is specified for one of the cylinder ports.
3. In 3-way VP segments if lower return flow (C₁ to T) is specified.

Adjustment Procedure

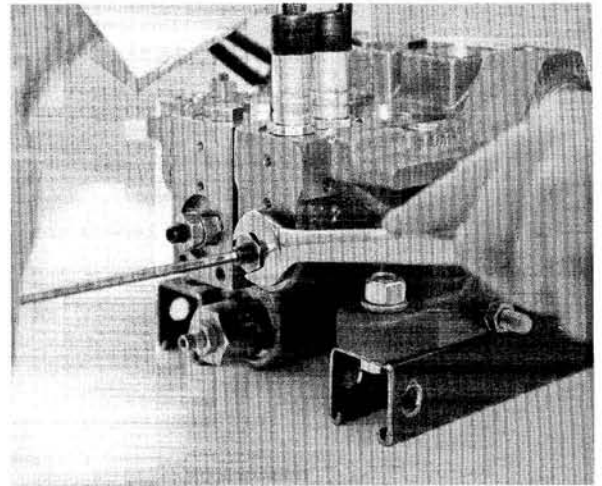
1. With the valve stack connected to supply pressure and tank, check that the flow limiting adjustment screws are backed out sufficiently as not to interfere with main spool movement.
2. Four-way VP or VQ adjustment:

With the load circuit and flow meter connected to the segment cylinder ports and the test stand "on," energize the Pulsar™ solenoid with 100 percent modulation ratio (M.R.) to produce load flow through the cylinder port to be adjusted. Check that pump relief valve is set high enough to saturate the cylinder port flow.

While holding the adjustment plug (Item 15 or 44) by the wrench flats, turn the adjustment screw (Item 17) until output flow equals the specified flow setting. After adjustment, hold the adjustment screw and adjustment plug, then tighten the lock nut with a torque of 5-10 ft-lbs. (7-14 Nm). To adjust flow through the other cylinder port, repeat this process with other solenoid and flow limiter.

3. Three-way (one cylinder port plugged) VP or VQ adjustment:

For three-way segments, it is necessary to furnish the singular cylinder port with access to a supply pressure line and flow meter to verify return flow. This access may be accomplished by (a) using a flow rectifier circuit, (b) by connecting a parallel pressure supply line to the cylinder port. Set supply pressure equal to load pressure on the application. Energize for 100% modulation ratio at the C₂ solenoid. While holding adjustment plug (Item 44), turn the adjustment screw (Item 17) until the output flow is equal to specified setting.



4. For flow limiters which do not require adjustment:

Back out the set screw (Item 17) until the internal upset screw thread contacts the adjustment plug. While holding the adjustment screw and plug, tighten the lock nut with a torque of 5-10 ft-lbs (7-14 Nm).

NOTE: All flow limiters are assembled in a retracted position, unless otherwise specified.

Pressure Limiter Adjustment

The pressure limiting feature is used to establish the maximum operating pressure available within the given segment. In the VP/VPO Series this is a "common" pressure limiter, where both C₁ and C₂ cylinder ports are controlled by the same setting.

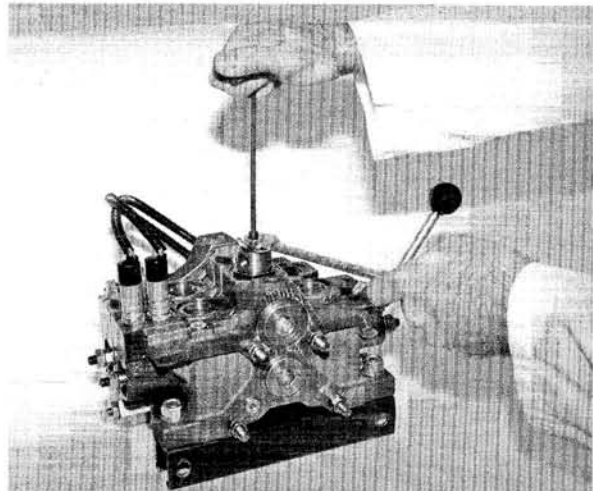
Have on Hand:

- 3/16" allen wrench
- 11/16" wrench

Adjustment Procedure

1. Flow through the segment is not required when setting the pressure limiter. However, a gauge must be connected to read the load on the dead headed cylinder port. Energize either C₁ or C₂ Pulsar with 100% M.R. to pressurize this cylinder port.
2. Turn the adjustment screw (Item 73) until the pressure is equal to the specified setting. Retighten the locking nut (Item 16) with a torque of 5-10 ft-lbs (7-14 Nm).

CAUTION: THESE ADJUSTMENT SCREWS ARE NOT SELF-CONTAINED. DO NOT ADJUST THE SCREW ALL THE WAY IN OR OUT.



Work Port Relief Adjustment

General

The taller VPO Series segments include the ability to relieve either cylinder port directly to tank at a predetermined pressure, thereby protecting the actuator circuit from shock loads. This feature can also be furnished with an anti-cavitation check.

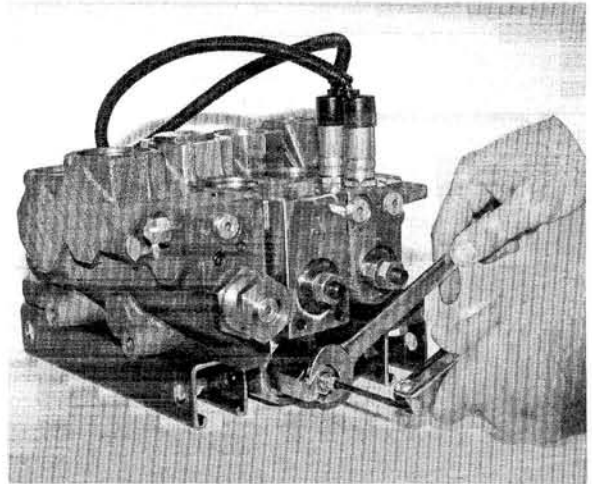
Have on hand:

- 17mm open end wrench
- 4mm allen wrench

Adjustment Procedure

1. Flow through the segment is not required for this adjustment. However, with the cylinder port blocked, a gauge must be connected to the cylinder port to read the relief setting. With the lock nut loosened, energize the Pulsar™ with 100% M.R. to pressurize the appropriate cylinder port.
2. Turn the adjustment screw until the pressure is equal to the specified setting. Lock the adjustment to 100 ft-lbs. (136 Nm).

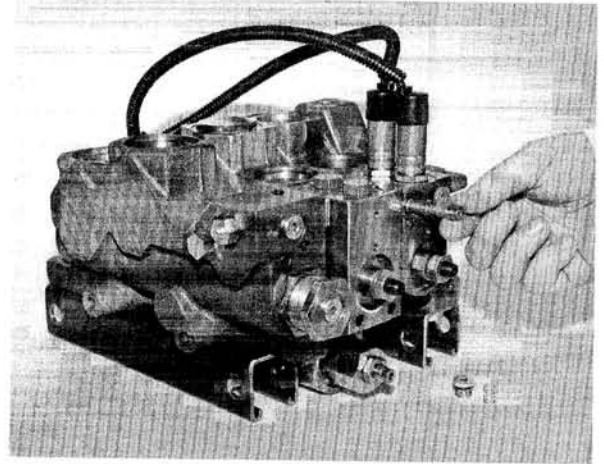
Note: As the cylinder port relief feature is intended to protect the actuator circuit against shock loads, the setting should typically exceed a segment pressure limiter adjustment by at least 250 PSI (17 bar).



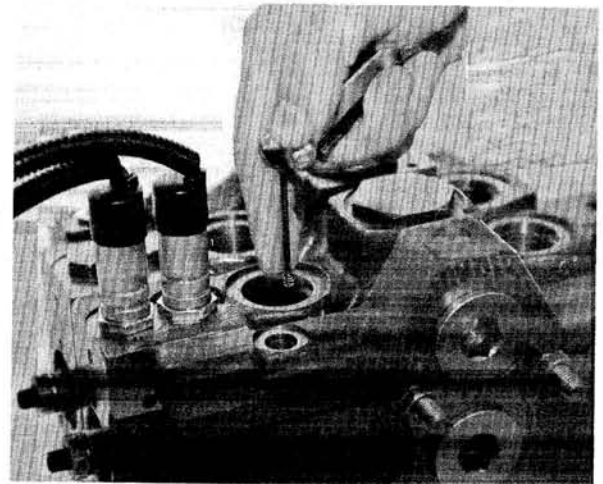
High Response Segment

General

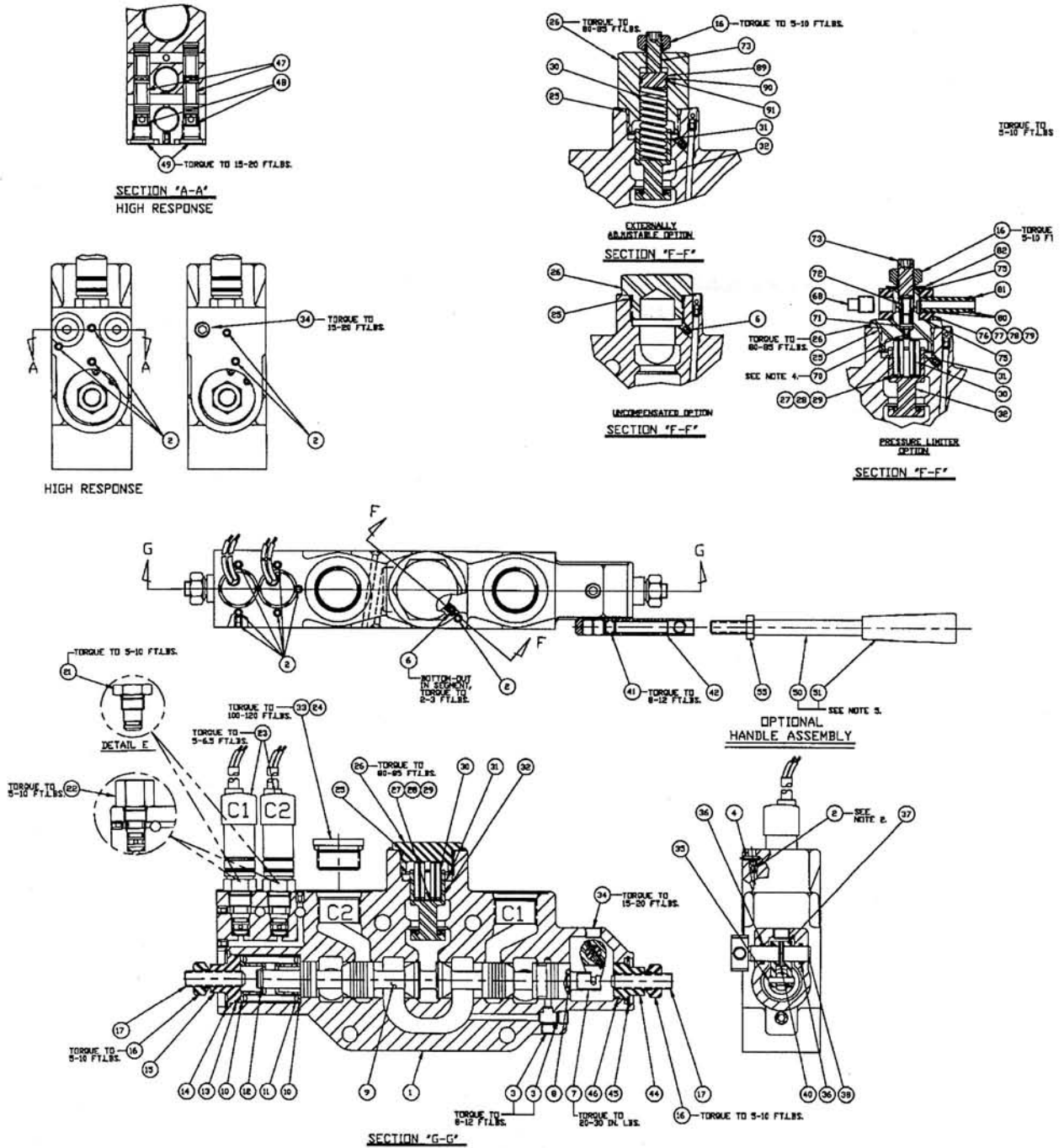
VP/VPO Series Segments may be equipped with high response capability. This feature reduces the time required for the main spool to shift from neutral to full displacement from 600 msec to 80 msec on a proportional spool. The accompanying photograph shows the location and access to the high response spool cavity. Adjustment of this feature typically takes place at Fluid Power Systems, therefore please consult the factory before making any adjustments in this area.



Additionally any stack that includes a high response segment requires the pilot drain be isolated and externally drained. As shown, this is accomplished by inserting a set screw in the drain port on the stacking plate and providing a separate line to tank.

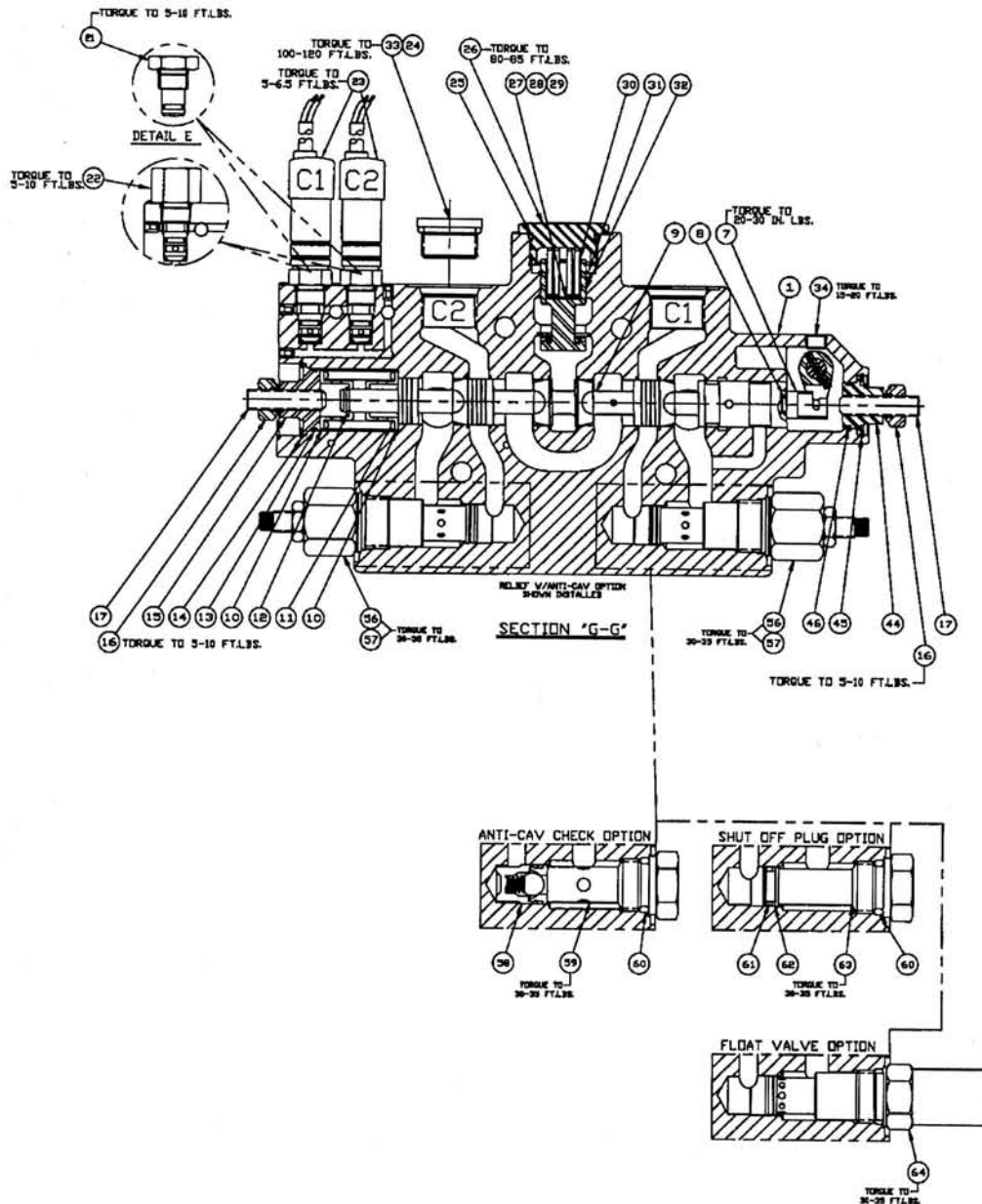


VP WORKING SEGMENT PARTS LIST



- | | | | | | | | |
|----|--------------------|----|--------------------|----|---------------------|----|--------------------|
| 1 | Valve Body | 21 | Solenoid Plug S/A | 37 | Clevis | 71 | Poppet Cone |
| 2 | Construction Plug | 22 | Adaptor Fitting | 38 | Shaft | 72 | Compression Spring |
| 3 | Plug | 23 | Solenoid S/A | 40 | Straight Pin | 73 | Set Screw |
| 4 | Spring Pin | 24 | Shipping Plug | 41 | Set Screw | 75 | O-Ring |
| 6 | Orifice Screw | 25 | O-Ring | 42 | Handle Adaptor | 76 | Manifold |
| 7 | Override Hook | 26 | Plug or Housing | 44 | Adjustment Plug | 77 | Manifold |
| 8 | O-Ring | 27 | Regulator Shim | 45 | Retaining Ring | 78 | Manifold |
| 9 | Main Spool | 28 | Regulator Shim | 46 | O-Ring | 79 | Manifold |
| 10 | Spring Guide | 29 | Regulator Shim | 47 | High Response Spool | 80 | O-Ring |
| 11 | Compression Spring | 30 | Compression Spring | 48 | Compression Spring | 81 | Tube |
| 12 | Retaining Ring | 31 | Retaining Ring | 49 | Steel Plug | 82 | Plate |
| 13 | O-Ring | 32 | Compensator Spool | 50 | Handle Rod | 89 | Piston |
| 14 | Retaining Ring | 33 | Steel Plug | 51 | Handle Knob | 90 | Back-Up Ring |
| 15 | Adjustment Plug | 34 | Pipe Plug | 55 | Lock Nut | 91 | O-Ring |
| 16 | Seal Nut | 35 | Dowel Pin | 68 | Shipping Plug | | |
| 17 | Set Screw | 36 | O-Ring | 70 | Seat | | |

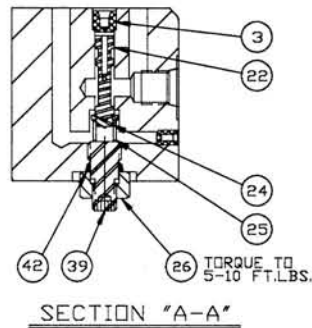
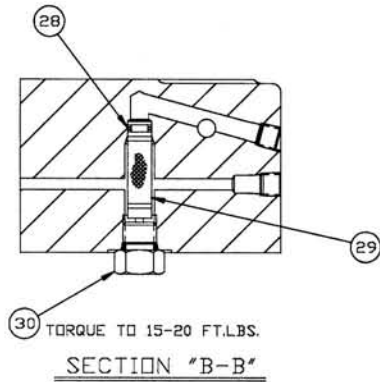
VPO WORKING SEGMENT PARTS LIST



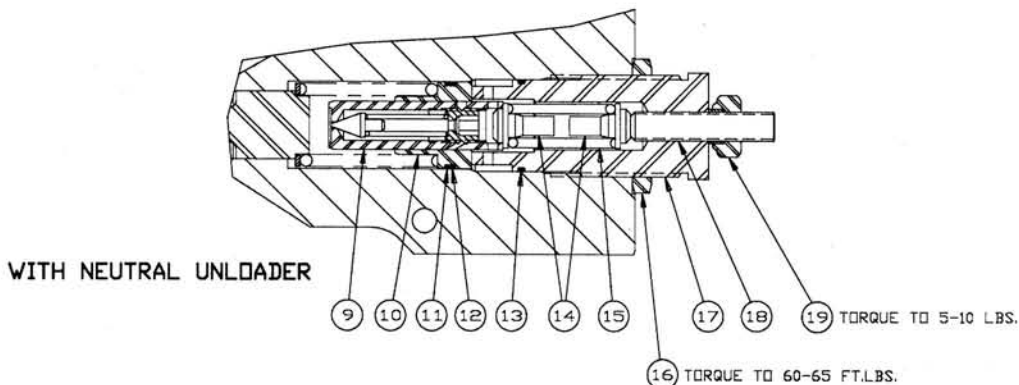
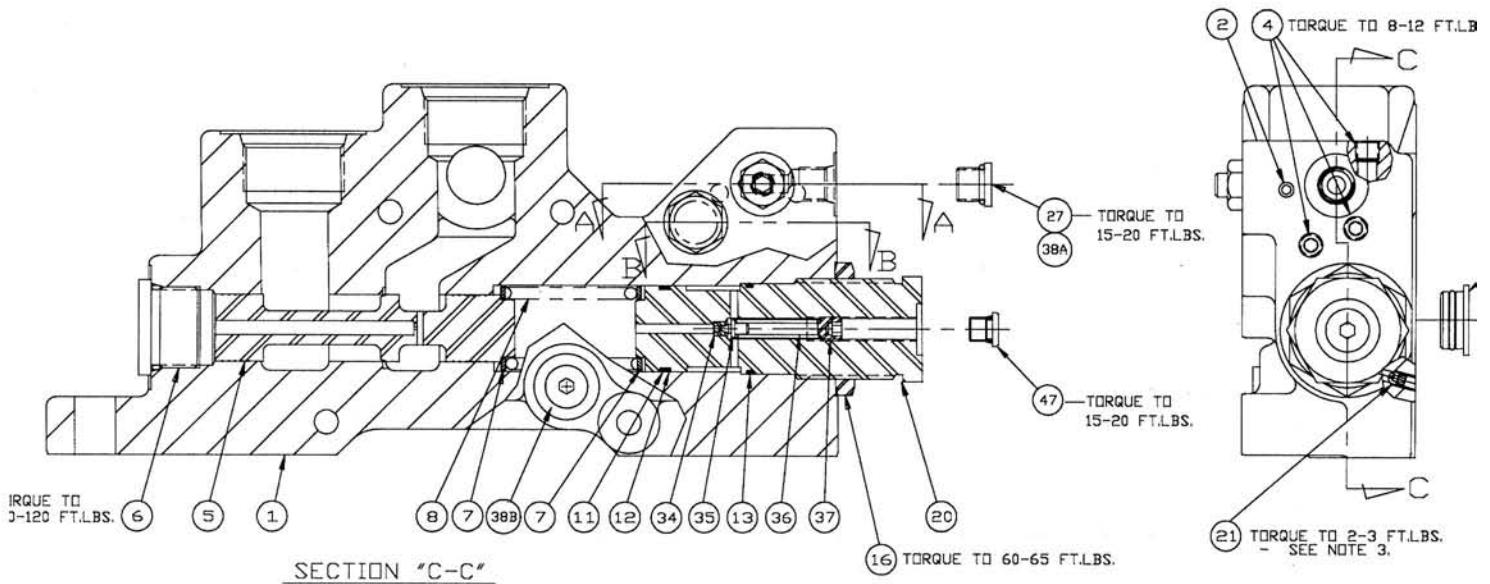
1 Valve Body	24 Shipping Plug	44 Adjustment Plug	68 Shipping Plug
2 Construction Plug	25 O-Ring	45 Retaining Ring	70 Seat
4 Spring Pin	26 Plug or Housing	46 O-Ring	71 Poppet Cone
6 Orifice Screw	27 Regulator Shim	47 High Response Spool	72 Compression Spring
7 Override Hook	28 Regulator Shim	48 Compression Spring	73 Set Screw
8 O-Ring	29 Regulator Shim	49 Steel Plug	75 O-Ring
9 Main Spool	30 Compression Spring	50 Handle Rod	76 Manifold
10 Spring Guide	31 Retaining Ring	51 Handle Knob	77 Manifold
11 Compression Spring	32 Compensator Spool	55 Lock Nut	78 Manifold
12 Retaining Ring	33 Steel Plug	56 Relief w/Anti-Cav	79 Manifold
13 O-Ring	34 Pipe Plug	57 Relief Valve	80 O-Ring
14 Retaining Ring	35 Dowel Pin	58 Check Valve	81 Tube
15 Adjustment Plug	36 O-Ring	59 Check Plug	82 Plate
16 Seal Nut	37 Clevis	60 O-Ring	89 Piston
17 Set Screw	38 Shaft	61 O-Ring	90 Back-Up Ring
21 Solenoid Plug	40 Straight Pin	62 Back-Up Ring	91 O-Ring
22 Adaptor Fitting	41 Set Screw	63 Shut Off Plug	
23 Solenoid S/A	42 Handle Adaptor	64 Float Valve	

VB BYPASS PRESSURE COMPENSATING INLET PARTS LIST

- 1 INLET PLATE
- 2 CONSTRUCTION PLUG
- 3 CONSTRUCTION PLUG
- 4 SOCKET HEX PLUG
- 5 SPOOL
- 6 SAE #12 HEX SOCKET
- 7 SPRING WASHER
- 8 COMPRESSION SPRING
- 9 RELIEF VALVE
- 10 LOADER HOUSING
- 11 O-RING
- 12 BACK-UP RING
- 13 O-RING
- 14 SPRING GUIDE
- 15 LOADER COMPRESSION SPRING
- 16 LOCK NUT
- 17 ADJUSTABLE PLUG
- 18 SET SCREW
- 19 SEAT NUT
- 20 ADJUSTABLE PLUG
- 21 ORIFICE SCREW
- 22 PILOT REDUCING SPOOL
- 24 SPRING GUIDE
- 25 PILOT REDUCING SPRING
- 26 PILOT VALVE LOCK NUT
- 27 SAE #4 HEX SOCKET
- 28 O-RING
- 29 FILTER
- 30 SAE #4 SOCKET HEX
- 32 SHIPPING PLUG
- 33 STEEL PLUG
- 34 RELIEF SEAT
- 35 POPPET CONE
- 36 COMPRESSION SPRING
- 37 SET SCREW
- 38 SHIPPING PLUG
- 39 PILOT VALVE ADJ. SCREW
- 42 O-RING
- 47 SAE #2 SOCKET HEX
- 48 POWER BEYOND PLUG KIT

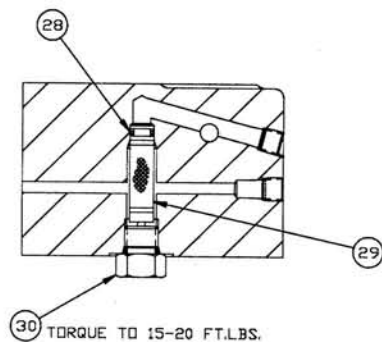


VB2211-*** OR VB2411-***

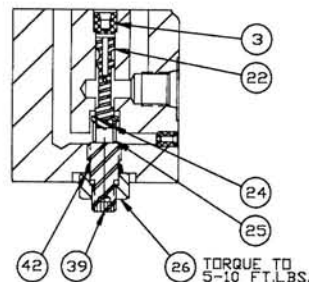


VY & VR PRESSURE COMPENSATING LIST PARTS LIST

- 1 INLET PLATE
- 2 CONSTRUCTION PLUG
- 3 CONSTRUCTION PLUG
- 4 SOCKET HEX PLUG
- 5 SPOOL
- 6 SAE #12 HEX SOCKET
- 7 SPRING WASHER
- 8 COMPRESSION SPRING
- 11 O-RING
- 12 BACK-UP RING
- 13 O-RING
- 16 LOCK NUT
- 20 ADJUSTABLE PLUG
- 22 PILOT REDUCING SPOOL
- 24 SPRING GUIDE
- 25 PILOT REDUCING SPRING
- 26 PILOT VALVE LOCK NUT
- 27 SAE #4 HEX SOCKET
- 28 O-RING
- 29 FILTER
- 30 SAE #4 SOCKET HEX
- 32 SHIPPING PLUG
- 33 STEEL PLUG
- 34 RELIEF SEAT
- 35 POPPET CONE
- 36 COMPRESSION SPRING
- 37 SET SCREW
- 38 SHIPPING PLUG
- 39 PILOT VALVE ADJ. SCREW
- 40 ORIFICE SCREW
- 41 SET SCREW
- 42 O-RING
- 47 SAE #2 SOCKET HEX

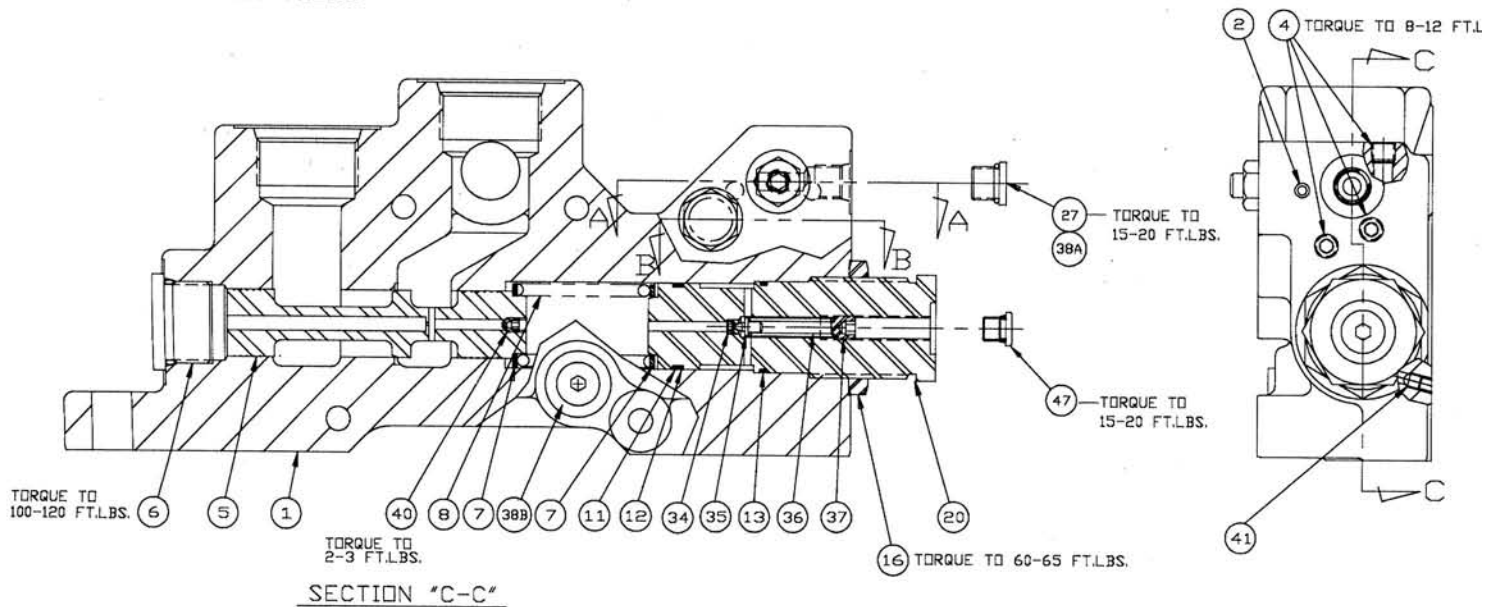


SECTION "B-B"



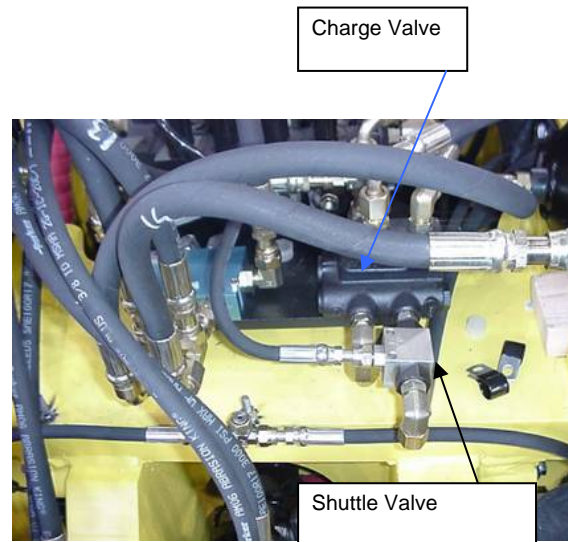
SECTION "A-A"

VY2211-~~REDACTED~~ OR VR2211-~~REDACTED~~



Hydraulic System-Shuttle Valve

- Change the filters and fluid first this will help to remove contamination.
- If experiencing interrupted steering and hydraulic functions. Check the shuttle valve.



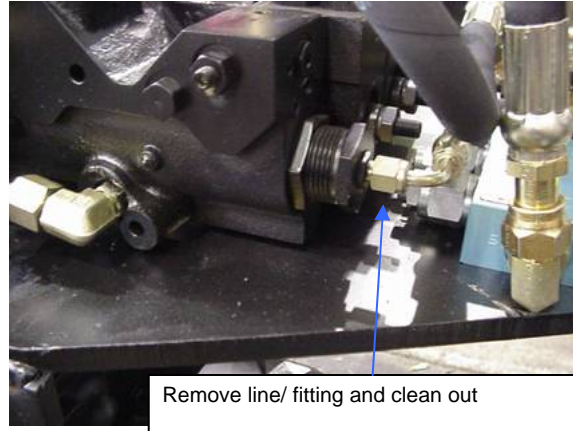
Hydraulic System-Shuttle Valve

- Carefully remove the shuttle from the control valve.
- Remove the fitting from the shuttle valve and clean out. The ball should move freely.



Hydraulic System-Load Sense Line

- If this did not solve the problem next, remove the load sense line from the control valve and clean out the orifices.



Remove line/ fitting and clean out

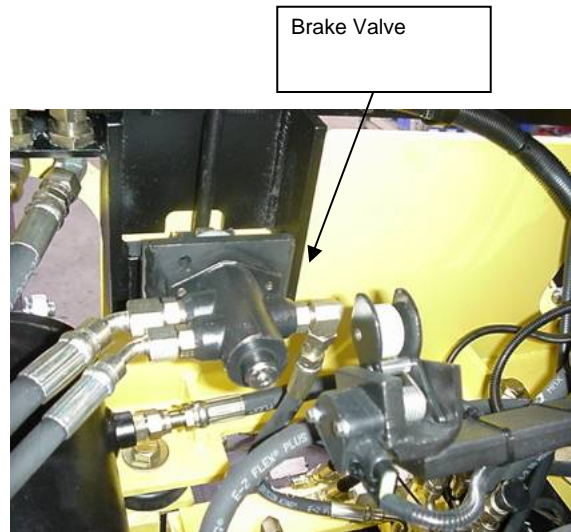
Hydraulic System-Charge Valve

- The charge valve is responsible for the brake and steering. Should this valve become contaminated it should not be taken apart. The charge valve is factory calibrated it must be replaced and can not be serviced.

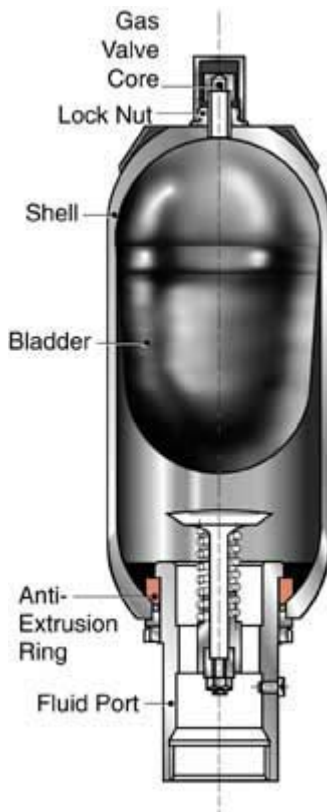


Brake Valve

The hydraulic brake valve modulates the braking pressure to the brake cylinders. Output pressure to the brake cylinders 0-1500psi



Accumulators



Description

Fluids are practically incompressible and cannot therefore store pressure energy.

The compressibility of a gas (nitrogen) is utilized in hydro-pneumatic accumulators for storing fluids. Bladder accumulators are designed on this principle, using nitrogen as the compressible medium.

The bladder accumulator consists of a fluid section and a gas section, with the bladder acting as a gas-proof screen. The fluid around the bladder is connected with the hydraulic circuit, so that the bladder accumulator draws in fluid when the pressure increases thus compressing the gas. When the pressure drops, the compressed gas expands and forces the stored fluid into the circuit.

ACCUMULATORS

Charging and Gauging Units

for Bladder, Diaphragm,
and Piston Accumulators

1. DESCRIPTION

To maintain system performance HOIST recommends a regular check of the gas precharge pressure. A loss in the gas precharge pressure will cause a drop in the system efficiency and could cause damage to the bladder, diaphragm, or piston accumulator.

By means of a charging and gauging unit, hydro-pneumatic accumulators are precharged with dry nitrogen or their existing gas precharge pressure is checked. For these purposes, a charging and gauging unit is connected to a commercially available nitrogen bottle via a flexible charging hose.

HOIST offers two types of charging and gauging units, the FPS model, used with HOIST gas valve version 4, except on top repairable bladder accumulators, and the FPK model used with HOIST gas valve version 1. An adapter FPK/SB can be used with the FPK model in order to fit HOIST gas valve version 4, including top repairable bladder accumulators.

The charging and gauging units incorporate a gauge, check valve in the charging connection, manual bleed valve, and T-handle.

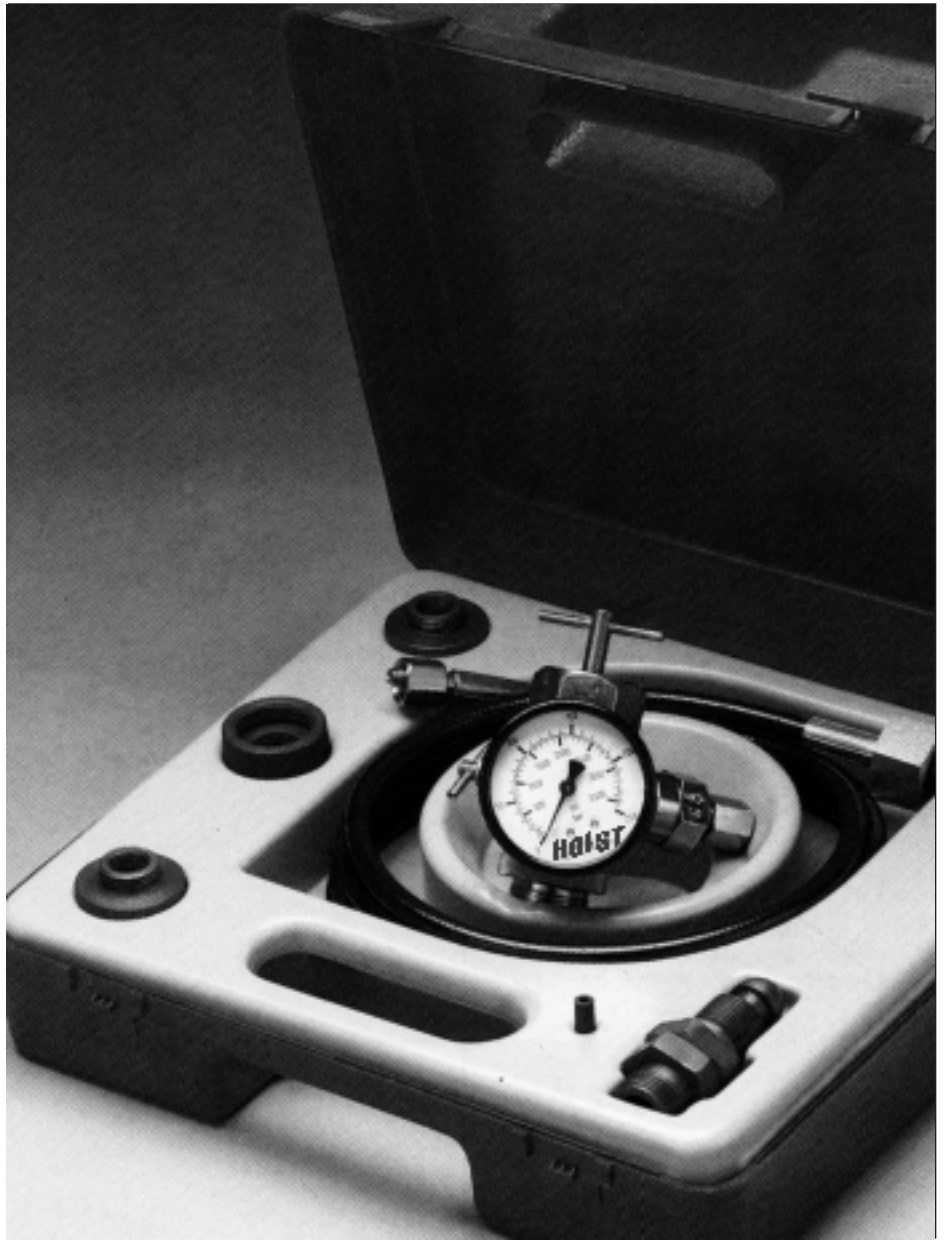
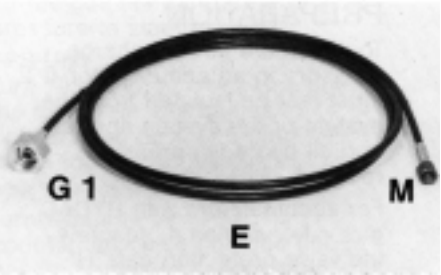
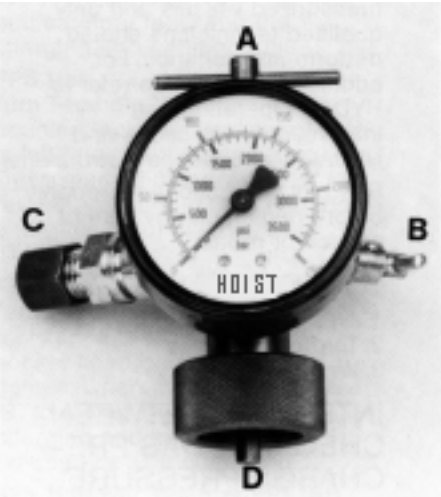
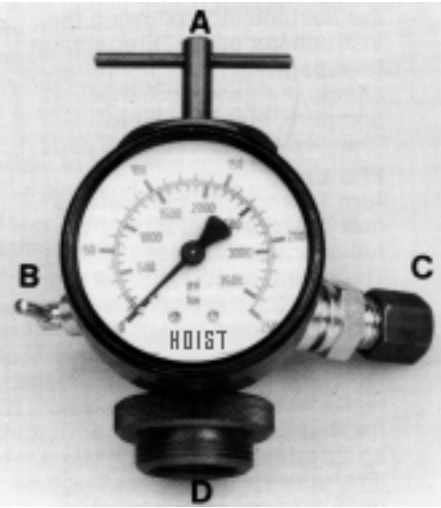


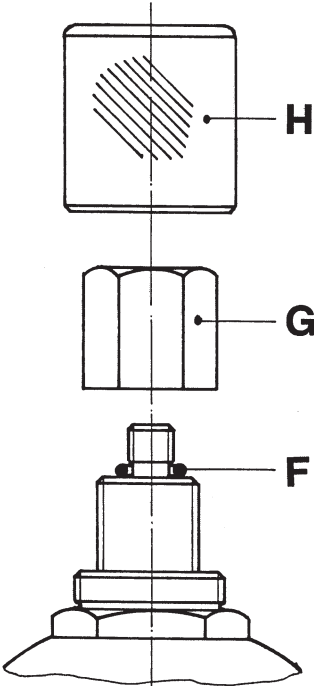
FIG.1: CHARGING AND GAUGING UNITS

FPS



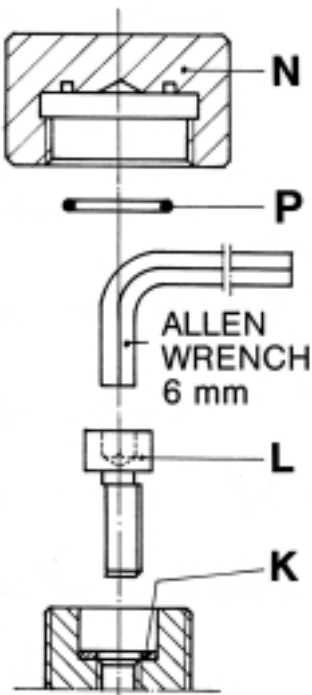
- A** T-handle
- B** manual bleed valve
- C** check valve
- D** cap nut
- E** charging hose, including cap screw connections G1 and M

FIG.2: HOIST STANDARD GAS VALVES



Version 4

- H** valve protection cap
(where applicable)
- G** valve seal cap
- F** O-ring



Version 1

- N** valve protection cap
(where applicable)
- M** O-ring
(where applicable)
- L** socket head cap screw (M8)
- K** seal ring

3. GENERAL

WARNING!

Hydraulic accumulators are pressurized vessels and only qualified technicians should perform maintenance. For additional information refer to HOIST Operating and Installation Instructions and HOIST Maintenance Instructions.

Read all instructions thoroughly before beginning any type of service or repair.

TOOLS REQUIRED

1. Gas Valve Core Tool.
2. Torque Wrenches.
3. Wrench(es).

INTERVALS BETWEEN CHECKING GAS PRECHARGE PRESSURE

The proper gas precharge pressure should be set after each new installation or repair by following the instructions under the Operating and Installation Instructions below. It should be rechecked at least once during the first week of operation. If there is no loss of gas precharge pressure, it should be rechecked again in 3 to 4 months. Thereafter, it should be checked at least once a year. Recharge accumulator when necessary.

TEMPERATURE EFFECT

To ensure that the recommended gas precharge pressure is maintained, even at relatively low of high operating temperatures, the gas precharge pressure should be adjusted for temperature. The formula below relates the precharge temperature (T_0) to the operating temperature (T).

Fahrenheit

$$P_{0,T_0} = P_{0,T_2} \times \left(\frac{T_0 + 460}{T_2 + 460} \right)$$

Celsius

$$P_{0,T_0} = P_{0,T_2} \times \left(\frac{T_0 + 273}{T_2 + 273} \right)$$

T_0 = precharge temperature

T_2 = maximum operating temperature

P_{0,T_0} = gas precharge pressure at precharge temperature

P_{0,T_2} = gas precharge pressure at maximum operating temperature

4. OPERATING AND INSTALLATION INSTRUCTION PREPARATION

To check the gas precharge pressure in an accumulator, it must first be isolated from the system shut off, and all hydraulic pressure relieved.

For accumulators with HOIST gas valve version 4, unscrew the valve protection cap "H" (where applicable) and the valve seal cap "G" (see fig. 2).

For accumulator with HOIST gas valve version 1, unscrew the valve protection cap "N" (where applicable). Slightly loosen the socket head cap screw "L" with a 6 mm Allen wrench (approx. 1/6 turn, see fig. 2).

FPS Unit

Prior to connecting the charging and gauging unit to an accumulator, turn T-handle "A" counter clockwise until resistance is felt. Close manual bleed valve "B" by hand tightening. Connect the unit to the accumulator by screwing cap nut "D" onto HOIST gas valve version 4; hand tighten (see fig.1).

FPK Unit

Prior to connecting the charging and gauging unit to an accumulator, close manual bleed valve "B" by hand tightening. Connect the unit to the accumulator by screwing cap nut "D" onto HOIST gas valve version 1; hand tighten (see fig.1).

FPK Unit (with adapter FPK/SB)

Prior to connecting the charging and gauging unit to an accumulator, take adapter FPK/SB (see fig. 6) and unscrew the socket head cap screw 3 full turns counter clockwise using the 6 mm Allen wrench. This is done to prevent gas valve damage and leakage upon installation. Screw the adapter FPK/SB onto HOIST gas valve version 4, hand tighten. Close manual bleed valve "B" on the FPK unit hand tight. Connect FPK unit to adapter FPK/SB by screwing cap nut "D" onto the adapter; hand tighten.

CHECKING GAS PRECHARGE PRESSURE

Connect the appropriate charging and gauging unit to the accumulator following the instructions under "Preparation" (see page 5).

Note: Temperature affects the gas precharge pressure, please refer to "Temperature Effect" (see page 5).

FPS Unit

Turn T-handle "A" clockwise a maximum of 3 full turns from the full counterclockwise position. The gauge needle should indicate the existing gas precharge pressure. If there is no gas precharge pressure indicated or if it is too low or too high, please follow instructions under the appropriate section, either "Pressure Release" (see page 5) or "Charging" (see page 6). If desired gas precharge pressure registers, please follow the instructions under "Removal of Charging and Gauging Unit" (see page 6).

FPK Unit

Turn T-handle counter clockwise a maximum of 3 full turns. The gauge needle should indicate the existing gas precharge pressure. If there is no gas precharge pressure indicated or if it is too low or too high, please follow instructions under the appropriate section, either "Pressure Release" (see page 5) or "Charging" (see page 6). If desired gas precharge pressure registers, please follow the instructions under "Removal of Charging and Gauging Unit" (see page 6).

PRESSURE RELEASE

With the appropriate charging and gauging unit attached as previously described, gas precharge pressure can be released by carefully opening manual bleed valve "B". Release the gas precharge pressure very slowly until the desired gas precharge pressure is reached (this insures that the gas temperature does not fluctuate greatly, providing and accurate gas precharge pressure). Close the manual bleed valve "B". Allow the gas precharge pressure to stabilize. (5 to 10 minutes) recheck, adjust if required. Once the desired gas precharge pressure is reached, please follow the instructions under "Removal of Charging and Gauging Unit" (see page 6).

CHARGING

WARNING!

Never use oxygen or air - this could cause an explosion! Use dry nitrogen or other recommended gases.

HOIST recommends the use of a pressure regulator on the commercially available nitrogen bottle to regulate pressure to the charging and gauging unit.

Note: Full nitrogen pressure may damage the gauge.

Connect the charging hose to a commercially available nitrogen bottle by means of the **G4** adapter (other adapters are available, check with factory for type); the adapter connects to the cap screw "G1". Connect cap nut "M" of the charging hose to check valve "C" of the charging and gauging unit (see fig. 1). Connect the appropriate charging and gauging unit to the accumulator by following the instructions previously described (see page 5).

INITIAL CHARGING

When charging an accumulator that has no initial gas precharge, allow 20 to 30 minutes for the gas temperature and thus pressure to stabilize. Recheck the gas precharge pressure and adjust if necessary.

FPS Unit

Turn T-handle "A" clockwise 3 full turns. Proceed to "Filling".

FPK Unit

Turn T-handle "A" counter clockwise 3 full turns. Proceed to "Filling".

FPK Unit *(with adapter FPK/SB)*

Turn T-handle "A" clockwise 3 full turns. Proceed to "Filling".

PRESSURE INCREASE

When charging an accumulator that has an existing gas precharge, allow 5 to 10 minutes for the gas temperature and thus pressure to stabilize.

FPS Unit

Turn T-handle "A" clockwise until the gauge needle begins to deflect, then turn it another full turn. Proceed to "Filling".

FPK Unit

Turn T-handle "A" counter clockwise until the gauge needle begins to deflect, then turn it another full turn. Proceed to "Filling".

FPK Unit *(con adapter FPK/SB)*

Turn T-handle "A" clockwise until the gauge needle begins to deflect, then turn it another full turn. Proceed to "Filling".

FILLING

Open the shut-off valve on the commercially available nitrogen bottle and slowly fill the accumulator with dry nitrogen gas.

Precharge very slowly until the pressure in the accumulator reaches 100 psi. Once 100 psi is reached, the charging rate can increase. Charging too quickly may damage the accumulator.

Note: The gauge registers the line pressure, not necessarily the accumulator pressure while charging.

After allowing the appropriate time for the gas temperature and thus pressure to stabilize, adjust the gas precharge pressure as required, refer to "Pressure Increase" (see page 6) or "Pressure Release" (see page 5).

Once the desired gas precharge pressure is reached close the shut-off valve on the commercially available nitrogen bottle. Remove the charging and gauging unit from the gas valve as described under "Removal of Charging and Gauging

Unit" (see page 6).

REMOVAL OF CHARGING AND GAUGING UNIT

Close the shut-off valve on the commercially available nitrogen bottle before removing the charging and gauging unit.

FPS Unit

Turn T-handle "A" counter clockwise until resistance is felt to close the gas valve. Open manual bleed valve "B" to relieve pressure in the charging and gauging unit. Proceed to "Disconnecting".

FPK Unit

Turn T-handle "A" clockwise until resistance is felt to close the socket head cap screw, hand tighten. Open manual bleed valve "B" to relieve pressure in the charging and gauging unit. Proceed to "Disconnecting".

FPK Unit *(with adapter FPK/SB)*

Turn T-handle "A" counter clockwise until resistance is felt to close the gas valve. Open manual bleed valve "B" to relieve pressure in the charging and gauging unit. Proceed to "Disconnecting".

DISCONNECTION

Unscrew the charging and gauging unit from the gas valve. Note: For FPK unit with adapter FPK/SB it may be necessary to loosen the connection between cap nut "D" and the adapter to remove the charging and gauging unit. Check for leaks. None are permissible.

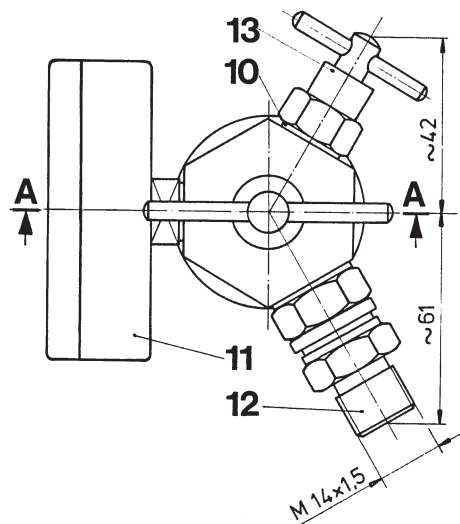
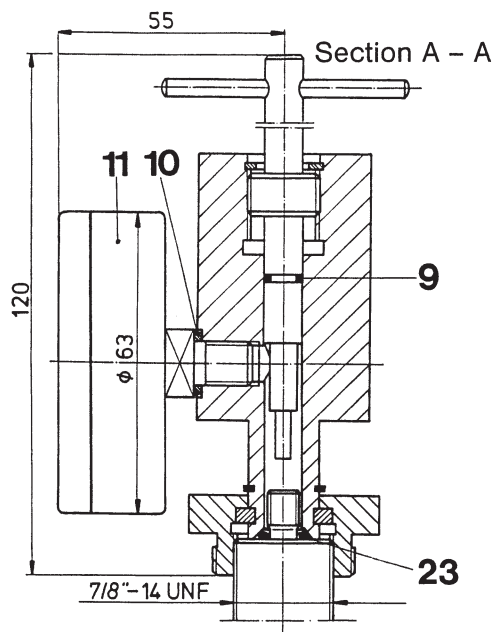
COMPLETION

For HOIST gas valve version 1, tighten socket head screw cap "L" to 20 Nm (15 lb-ft), and screw on valve protection cap "N" (where applicable); hand tighten. For HOISTt gas valve version 4, screw on valve seal cap "G" torquing to 30 Nm (22 lb-ft), and valve protection cap "H" (where applicable); hand tighten.

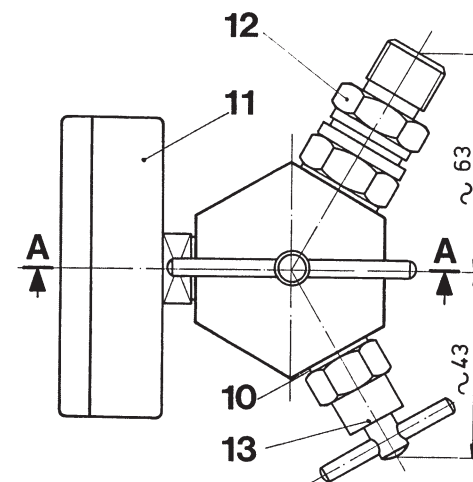
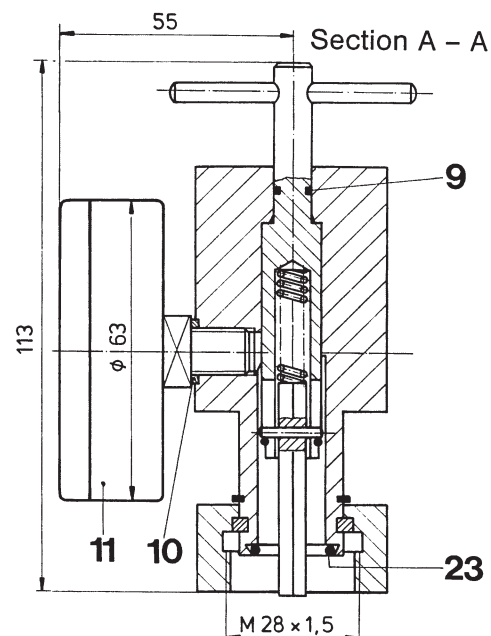
5. DIMENSION OF CHARGING AND GAUGING UNIT

Fig.3: Units FPS and FPK

FPS



FPK



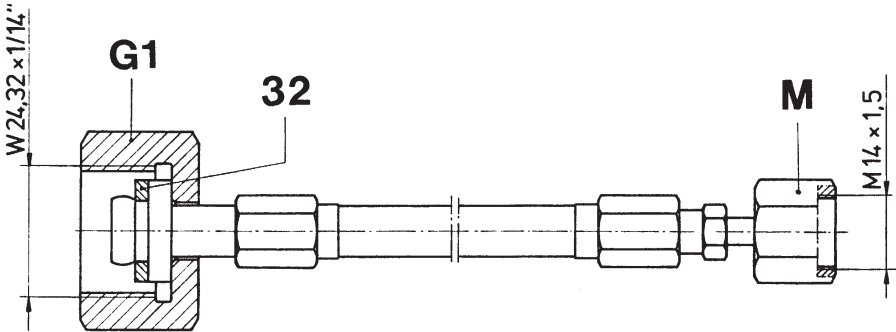
6. SPARE PARTS

Charging and Gauging Unit Type:					
FPS			FPK		
Item	Description	Dimensions	Quantity	Dimension	Quantity
9	O-Ring	6 x 1	1	6 x 1	1
10	Seal-Ring	A 10 x 13.5	1	A 10 x 13.5	1
11	Gauge	Ø 63, conn. G 1/8 (ISO 228)	1	Ø 63, conn. G 1/8 (ISO 228)	1
12	Check Valve	DN 3	1	DN 3	1
13	Manual Bleed Valve	Connection M 10x1	1	Connection M10x1	1
23	O-Ring	7.5 x 2	1	15 x 2	1
32	Seal-Ring	Ø 20/11.5 x 2 elastomer ring	1	Ø 20/11.5 x 2 elastomer ring	1

Note: Dimensions in mm.

ADAPTER DIMENSIONS

Fig.5: Charging Hose



Length 2.5 m (standard)
Length 4.0 m (optional)

Fig.6: Adapter G4

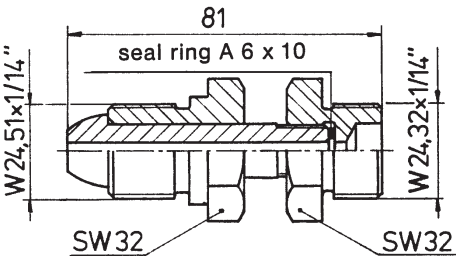
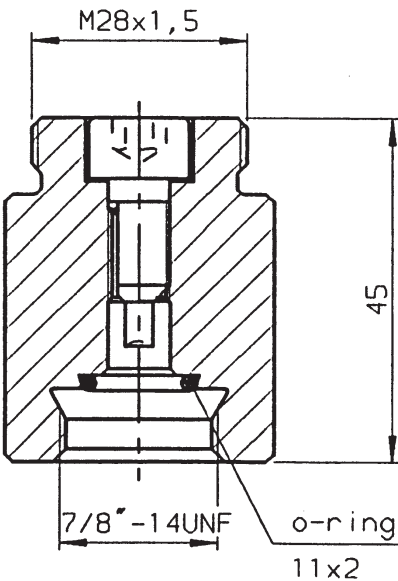


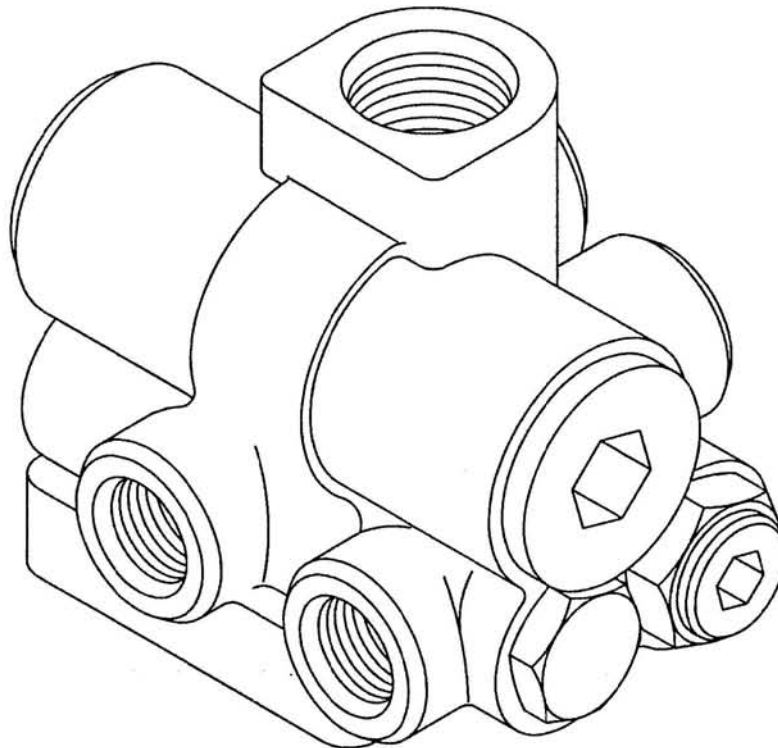
Fig.7: Adapter FPK/SB



Note: Dimensions shown in mm

463 Series - 30 GPM Single ACCUMULATOR CHARGING VALVE

Service Instructions



MICO could not possibly know of and give advice with respect to all conceivable applications in which this product may be used and the possible hazards and/or results of each application. MICO has not undertaken any such wide evaluation. Therefore, anyone who uses an application which is not recommended by the manufacturer, first must completely satisfy himself that a danger will not be created by the application selected, or by the particular model of our product that is selected for the application.

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DISASSEMBLY

1. Remove plug (1) from housing (7). Remove o-ring (2) from plug. **Note: Plug is under spring tension.**
2. Remove spring (4) and rod (3) from housing.
3. Remove plug (9) from housing. Remove o-ring (8) from plug.
4. Remove spool (6) from housing thru plug (1) end **ONLY**. Remove seal (5) from spool.
5. Loosen nut (10) and remove screw assembly (11) from housing. Remove o-ring (12) from screw assembly.
6. Remove spring (13), poppet or steel ball (14), seat (15), o-ring (16), washer (17), filter (18) and washer (19) from housing.
7. Remove plug (34) from housing. Remove o-ring (33) from plug.
8. **BEFORE** moving screw (32), **ACCURATELY MEASURE ITS DEPTH** from the end of housing and record for reassembly purposes. Remove screw (32) from housing.
9. Remove spring (31), retainer (30) and ball (29). Be sure to keep ball (29) separate from ball (24) for reassembling.
10. Remove plug (35) from screw (32) using a drive pin punch. Be careful not to damage threads.
11. Remove plug (20) from housing. Remove o-ring (21) from plug.
12. Remove spring (22), stop (23) and ball (24) from housing.
13. Place housing on bench with plug (20) end down. Spool (25) may or may not fall out at this point.
14. Using a 1/4"-5/16" dia. wood or plastic dowel, carefully remove insert (26) and spool (25) from housing. Insert (26) must come out plug (20) end of housing. Be careful not to scratch or mar valve seats on insert (26).
15. Remove spool (25) from insert (26). Remove o-rings (27 & 28) from insert.

ASSEMBLY

CLEAN ALL PARTS WITH CLEAN SOLVENT AND DRY. LUBRICATE ALL RUBBER PARTS WITH CLEAN SYSTEM FLUID PRIOR TO ASSEMBLY. BE SURE ENTIRE ASSEMBLY PROCEDURE IS DONE WITH CONTAMINATION FREE METHODS.

1. Install new o-ring (8) on plug (9) and torque into housing 54.2-67.8 N-m (40-50 lb-ft).
2. Install new seal (5) on spool (6). Be sure seal does not twist in groove.
3. Lubricate spool (6) and properly insert into housing.
4. Install spring (4) and rod (3) into housing.
5. Install new o-ring (2) on plug (1) and torque into housing 54.2-67.8 N-m (40-50 lb-ft).
6. Install new o-rings (27 & 28) on insert (26) and place into housing. Note direction of assembly. Seat insert with 1/2" dia. wood dowel.
7. Install spool (25) into insert (26) in housing. Note direction of spool, long shoulder end is up toward end plug (20).
8. Install ball (24) on insert (26) in housing. Install stop (23) over ball and spring (22) over stop correctly.
9. Install new o-ring (21) on plug (20) and carefully install into housing, centering spring (22). Torque 54.2-67.8 N-m (40-50 lb-ft).
10. Turn housing so plug (9) is vertically upward. Install ball (29), 6.4 mm (.25") dia. Be sure ball is centered in bottom of hole in housing. Drop retainer (30) and spring (31) into housing.
11. Insert new plug (35) in screw (32). Be sure plug is aligned properly and is evenly driven into screw. Do not damage threads.

12. Thread screw (32) in housing to the depth recorded during disassembly.
13. Install new o-ring (33) on plug (34). Install plug in housing and tighten.
14. Install new o-ring (12) on screw assembly (11).
15. Install washer (19), new filter (18), washer (17), new o-ring (16), seat (15), new poppet or steel ball (14), spring (13) and screw assembly (11) into housing. Torque screw 24.4-29.8 N-m (18-22 lb-ft).
16. Install nut (10) on screw assembly (11) and torque 43.4-51.5 N-m (32-38 lb-ft).

VALVE ADJUSTMENT

(Refer to Table 1)

1. Reinstall valve correctly. Tee an accurate pressure gauge into the accumulator line.
2. Start pump and allow approximately one minute for charging to start (pressure in gauge will read accumulator precharge plus). If valve does not begin to charge, turn screw (32) in, stopping when gauge shows an increase in pressure. Check the high limit specifications (see chart) and adjust screw (32) until the high limit setting is met. This pressure can be checked correctly only if after each adjustment of screw (32) the accumulator pressure is reduced below the low limit setting and the system recharges the accumulator pressure to its high limit.
3. Once the high limit setting is accurately adjusted, install o-ring (33) on end plug (34). Install end plug (34) in housing (7) and torque 33.9-47.5 N-m (25-35 lb-ft).

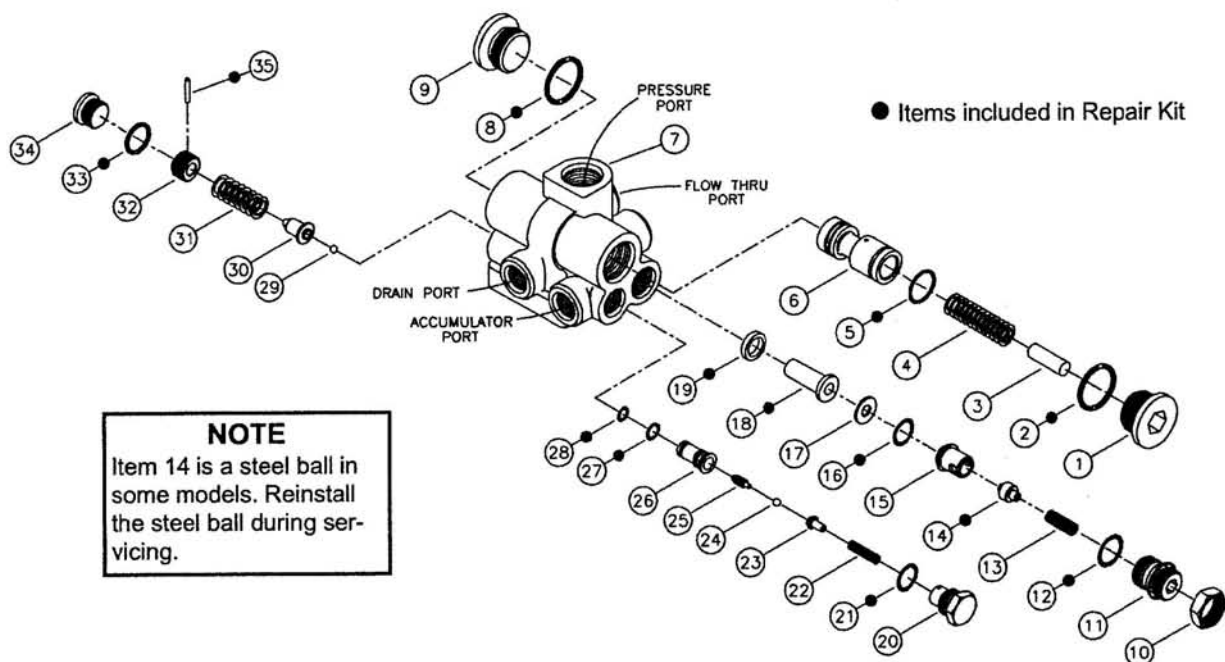


TABLE 1 (Specifications)

Model Number	Accumulator Charge Rate		Accumulator High Limit		Accumulator Low Limit	
	L/min	(gpm)	bar	(psi)	bar	(psi)
06-463-006	6.4 ± 1.9	(1.7 ± .5)	103.4 ± 3.4	(1500 ± 50)	82.8 ± 3.4	(1200 ± 50)
06-463-008	10.2 ± 1.9	(2.7 ± .5)	94.8 ± 1.7	(1375 ± 25)	67.2 ± 3.4	(975 ± 50)
06-463-010	10.2 ± 1.9	(2.7 ± .5)	89.7 ± 1.7	(1300 ± 25)	41.4 ± 3.4	(600 ± 50)
* 06-463-012	6.4 ± 1.9	(1.7 ± .5)	124.1 ± 3.4	(1800 ± 50)	93.9 ± 2.6	(1362 ± 38)
06-463-014	6.4 ± 1.9	(1.7 ± .5)	75.9 ± 3.4	(1100 ± 50)	55.2 ± 3.4	(800 ± 50)
06-463-016	6.4 ± 1.9	(1.7 ± .5)	103.4 ± 3.4	(1500 ± 50)	82.8 ± 3.4	(1200 ± 50)
06-463-018	10.2 ± 1.9	(2.7 ± .5)	189.7 ± 3.4	(2750 ± 50)	144.8 ± 3.4	(2100 ± 50)
06-463-020	10.2 ± 1.9	(2.7 ± .5)	158.6 ± 3.4	(2300 ± 50)	127.6 ± 3.4	(1850 ± 50)
06-463-022	10.2 ± 1.9	(2.7 ± .5)	186.2 ± 3.4	(2700 ± 50)	155.1 ± 1.7	(2250 ± 25)
06-463-024	10.2 ± 1.9	(2.7 ± .5)	127.6 ± 3.4	(1850 ± 50)	103.4 ± 3.4	(1500 ± 50)
06-463-026	2.8 ± .95	(.75 ± .25)	137.9 ± 3.4	(2000 ± 50)	103.4 ± 3.4	(1500 ± 50)
06-463-028	10.2 ± 1.9	(2.7 ± .5)	124.1 ± 3.4	(1800 ± 50)	93.9 ± 2.6	(1362 ± 38)
* 06-463-030	6.4 ± 1.9	(1.7 ± .5)	75.9 ± 3.4	(1100 ± 50)	55.2 ± 3.4	(800 ± 50)
* 06-463-032	10.2 ± 1.9	(2.7 ± .5)	127.6 ± 3.4	(1850 ± 50)	103.4 ± 3.4	(1500 ± 50)
* 06-463-034	6.4 ± 1.9	(1.7 ± .5)	151.7 ± 3.4	(2200 ± 50)	124.1 ± 3.4	(1800 ± 50)
06-463-036	17.0 ± 1.9	(4.5 ± .5)	137.9 ± 3.4	(2000 ± 50)	113.8 ± 3.4	(1650 ± 50)
06-463-038	2.8 ± .95	(.75 ± .25)	124.1 ± 3.4	(1800 ± 50)	86.2 ± 3.4	(1250 ± 50)
06-463-040	10.2 ± 1.9	(2.7 ± .5)	137.9 ± 3.4	(2000 ± 50)	113.8 ± 3.4	(1650 ± 50)
06-463-044	3.8 ± 1.1	(1.0 ± .3)	124.1 ± 3.4	(1800 ± 50)	86.2 ± 3.4	(1250 ± 50)
06-463-048	6.4 ± 1.9	(1.7 ± .5)	137.9 ± 3.4	(2000 ± 50)	103.4 ± 3.4	(1500 ± 50)
06-463-050	6.4 ± 1.9	(1.7 ± .5)	144.8 ± 3.4	(2100 ± 50)	117.2 ± 3.4	(1700 ± 50)
* 06-463-052	6.4 ± 1.9	(1.7 ± .5)	137.9 ± 3.4	(2000 ± 50)	113.8 ± 3.4	(1650 ± 50)
06-463-054	2.8 ± .95	(.75 ± .25)	103.4 ± 3.4	(1500 ± 50)	72.4 ± 3.4	(1050 ± 50)
06-463-056	2.8 ± .95	(.75 ± .25)	124.1 ± 3.4	(1800 ± 50)	93.1 ± 3.4	(1350 ± 50)
06-463-058	2.8 ± .95	(.75 ± .25)	137.9 ± 3.4	(2000 ± 50)	113.8 ± 3.4	(1650 ± 50)
06-463-060	2.8 ± .95	(.75 ± .25)	60.3 ± 1.7	(875 ± 25)	44.8 ± 1.7	(650 ± 25)
06-463-064	2.8 ± .95	(.75 ± .25)	158.6 ± 3.4	(2300 ± 50)	127.6 ± 3.4	(1850 ± 50)
06-463-066	6.4 ± 1.9	(1.7 ± .5)	89.7 ± 1.7	(1300 ± 25)	48.3 ± 3.4	(700 ± 50)

* Water emulsion models.

SERVICE CHECKS FOR HYDRAULIC SYSTEMS

ACCUMULATOR CHARGING CYCLE REPEATS FREQUENTLY WHEN ACCUMULATOR IS NOT NORMALLY BEING DISCHARGED IN SERVICE

1. Leaking accumulator lines or fittings
1. **Check lines and fittings for leaks and correct**
2. Incorrect setting of accumulator gas charge
2. **Check accumulator gas charge**
3. Line to accumulator plugged
3. **Replace line**
4. Inoperative charging valve
4. **Replace charging valve**

ACCUMULATOR STARTS TO CHARGE BUT DOES NOT REACH HIGH LIMIT

1. No oil or low oil level in tank
1. **Check oil level**
2. Pump worn or inoperative and not delivering full flow or pressure
2. **Check pump**
3. Inoperative system relief valve (valve leaking or has low setting so full flow and pressure are not available)
3. **Check relief valve**
4. Inoperative charging valve
4. **Replace charging valve**

ACCUMULATOR CHARGING TIME TOO LONG

1. No oil or low oil level in tank
1. **Check oil level**
2. Relief valve setting too low
2. **Check valve setting**
3. Pump worn or inoperative and not delivering full flow or pressure
3. **Check pump**
4. Inoperative charging valve
4. **Replace charging valve**

ACCUMULATOR FAILS TO START CHARGING

1. No oil or low oil level in tank
1. **Check oil level**
2. Worn or defective pump
2. **Check pump pressure and flow**
3. Inoperative relief valve
3. **Check relief valve setting**
4. Air in accumulator line
4. **Bleed accumulator line**
5. Inoperative charging valve
5. **Replace charging valve**

VERY RAPID CYCLING OF CHARGING VALVE

1. Incorrect setting of accumulator gas charge
1. **Check accumulator gas charge**
2. Inoperative charging valve
2. **Replace charging valve**

LACK OF ADEQUATE FLOW THRU VALVE

1. Inoperative pump
1. **Check pump pressure and delivery**
2. Inoperative relief valve
2. **Check relief valve setting**
3. Blocked lines
3. **Replace lines**
4. Inoperative charging valve
4. **Replace charging valve**

SERVICE DIAGNOSIS

ACCUMULATOR CHARGING CYCLE REPEATS FREQUENTLY WHEN ACCUMULATOR IS NOT NORMALLY BEING DISCHARGED IN SERVICE

1. Poppet (14) leaking.
2. O-ring (16) leaking.
3. O-ring (27) leaking.
4. Ball (24) leaking.
5. Inoperative seat on insert (26).

ACCUMULATOR STARTS TO CHARGE BUT DOES NOT REACH HIGH LIMIT

1. O-ring (28) leaking.
2. Seal (5) on spool (6) has been damaged or worn.

ACCUMULATOR CHARGING TIME TOO LONG

1. Dirt in filter (18).
2. Poppet (14) stuck, partially closed.
3. Seat (15) partially plugged

ACCUMULATOR FAILS TO START CHARGING

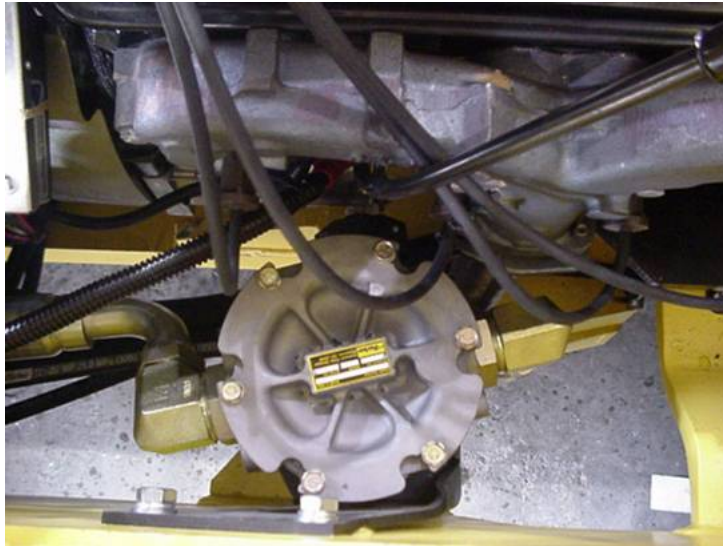
1. Broken spring (31).
2. Broken spring (4).
3. Seal (5) inoperative.
4. Spool (6) stuck.
5. Dirt in filter (18).

VERY RAPID CYCLING OF CHARGING VALVE

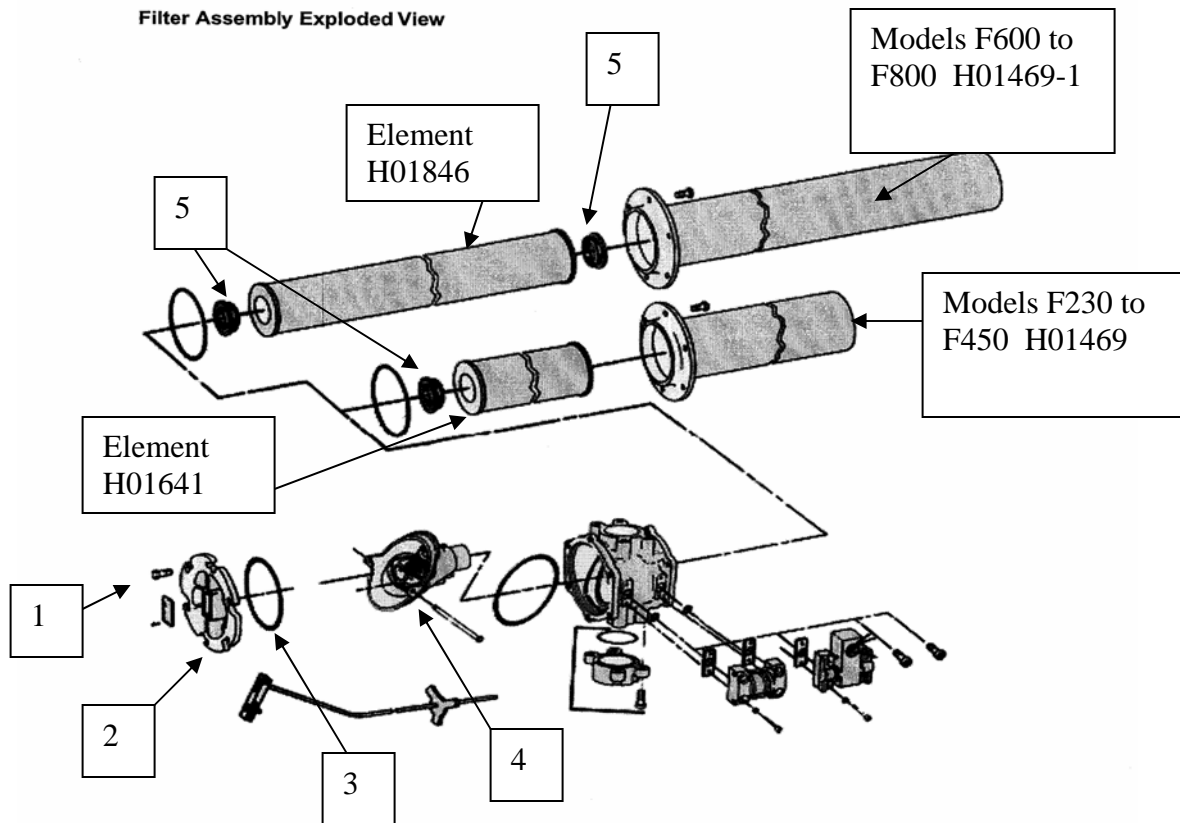
1. Insert (26) worn.

Return Line Filter

Please change at 250hrs. Located in the engine compartment left side.



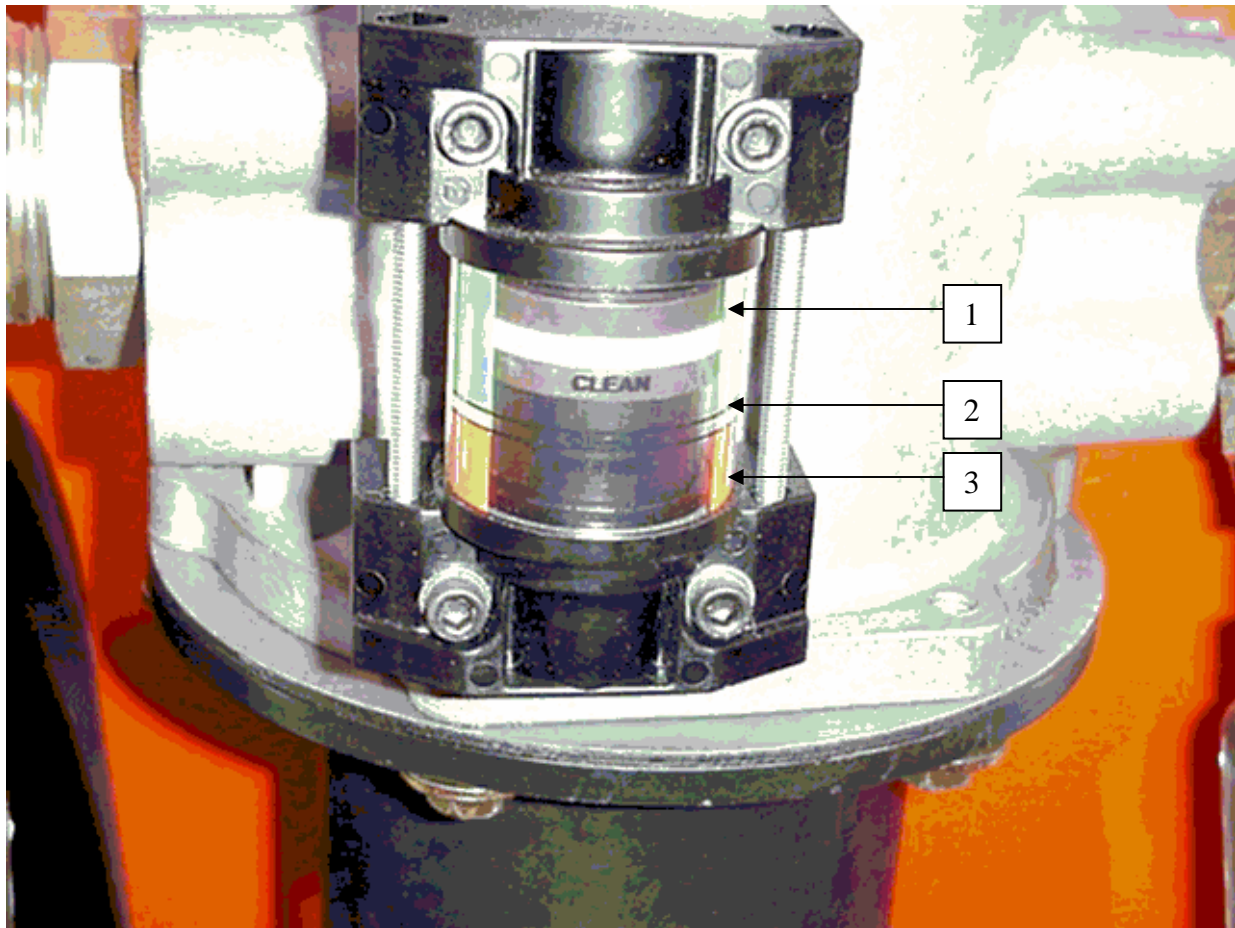
RETURN LINE FILTER ELEMENT



To change the filter element clean the surrounding area making sure it is free of dirt and grease to prevent contamination and hydraulic leaks.

1. Loosen the 6 cover screws (Item 1) **NOTE** Do not remove them!
2. Turn the slotted cover (Item 2) counter clockwise unlock and remove it.
3. Remove the O-ring (Item 3) **NOTE** inspect and replace if necessary
4. Remove the diverter/bypass valve assembly (Item 4)
5. Pull out element and replace with the proper part #
6. Reinstall element making sure the grommet (Item 5) is in place **NOTE** part # H01846 has 2 grommets
7. Reinstall the diverter/bypass valve assembly (item 4)
8. Reinstall the O-ring make sure it is in proper position (Item 3)
9. Reinstall the slotted cover (Item 2) turn it clockwise to lock.
10. Torque the cover screws (Item 1) in a star pattern.

LOW PRESSURE FILTER MODUFLOW “V” OPTION-VISUAL INDICATOR



The Visual Indicator is used to measure pressure drop across the filter. The colored bands indicate the condition the filter is in.

1. **Green = Normal operating condition**
2. **Yellow = Change the filter**
3. **Red = Bypass condition**

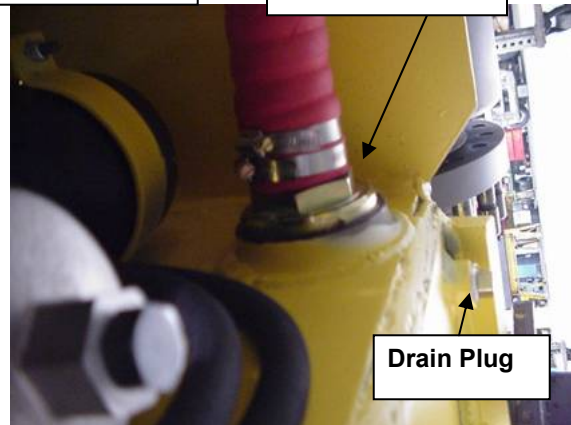
NOTE: View while lowering the mast at full speed in order to get the correct measurement.

Suction Filter

NOTE: This picture was taken from under side of the truck

**Suction inside tank.
Drain hydraulic oil
before attempting to
change the filter**

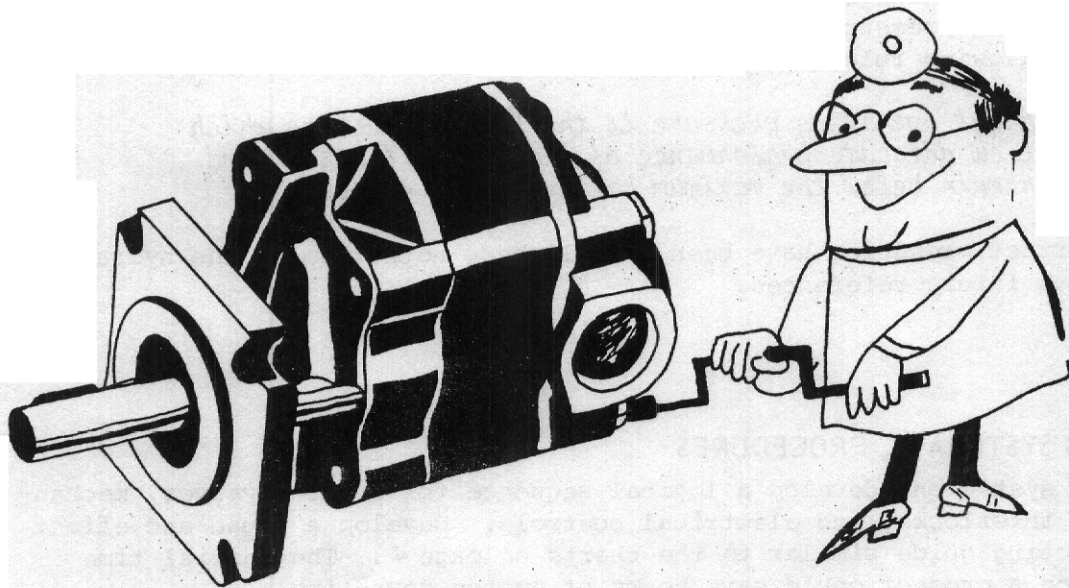
Change suction filter when changing the hydraulic fluid at 1000hrs. Located in the tank on the left side of the truck. Use AW32 Hydraulic fluid



HYDRAULIC TROUBLE-SHOOTING

IN GENERAL

..... the trouble-shooting charts and maintenance hints that follow are of a general system nature but should provide an intuitive feeling for a specific system. The more general information is covered in the immediately following paragraphs. Effect and probable cause charts start on page 4.



There is, of course, little point in discussing the design of a system which has been operating satisfactorily for a period of time. However, a seemingly uncomplicated procedure such as relocating a system or changing a component part can cause problems. Because of this, the following points should be considered.

- A. Each component in the system must be compatible with and form an integral part of the system. For example, an inadequate size filter on the inlet of a pump can cause cavitation and subsequent damage to the pump.
- B. All lines must be of proper size and free of restrictive bends. Undersize or restricted line results in a pressure drop in the line itself.
- C. Some components must be mounted in a specific position with respect to other components or the lines. The housing of an in-line pump, for example, must remain filled with fluid to provide lubrication.
- D. The inclusion of adequate test points for pressure readings, although not essential for operation, will expedite trouble-shooting.

KNOWING THE SYSTEM

Probably the greatest aid to trouble-shooting is the confidence of knowing the system. Every component has a purpose in the system. The construction and operation characteristics of each one should be understood. Some additional practices which will increase your ability and also the useful life of the system follow:

- A. Know the capabilities of the system. Each component in the system has a maximum rated speed, torque, or pressure. Loading the system beyond the specification simply increases the possibility of failure.
- B. Know the correct operating pressures. Always set and check pressures with a gauge. How else can you know if the operating pressure is above maximum rating of the components? The question may arise as to what the correct operating pressure is. If it isn't specified on the hydraulic schematic, the following rule should be applied:

The correct operating pressure is the lowest pressure which will allow adequate performance of the system function and still remain below the maximum rating of the components.

Once the correct pressures have been established, note them on the hydraulic schematic for future references.

DEVELOPING SYSTEMATIC PROCEDURES

Analyze the system and develop a logical sequence for setting valves, mechanical stops, interlocks, and electrical controls. Develop a cause and effect trouble-shooting guide similar to the charts on page 4. The initial time spent on such a project could save hours of system down-time.

RECOGNIZING TROUBLE INDICATIONS

The ability to recognize trouble indications in a specific system is usually acquired with experience. However, a few general trouble indications can be discussed.

- A. Excessive heat means trouble. A mis-aligned coupling places an excessive load on bearings and can be readily identified by the heat generated. A warmer than normal tank return line on a relief valve indicates operation at relief valve setting. Hydraulic fluids which have a low viscosity will increase the internal leakage of components resulting in a heat rise. Cavitation and slip-page in a pump will also generate heat.

B. Excessive noise means wear, mis-alignment, cavitation or air in the fluid. Contaminated fluid can cause a relief valve to stick and chatter. These noises may be the result of dirty filters, or fluid, high fluid viscosity, excessive drive speed, low reservoir level, or loose intake lines.

MAINTENANCE

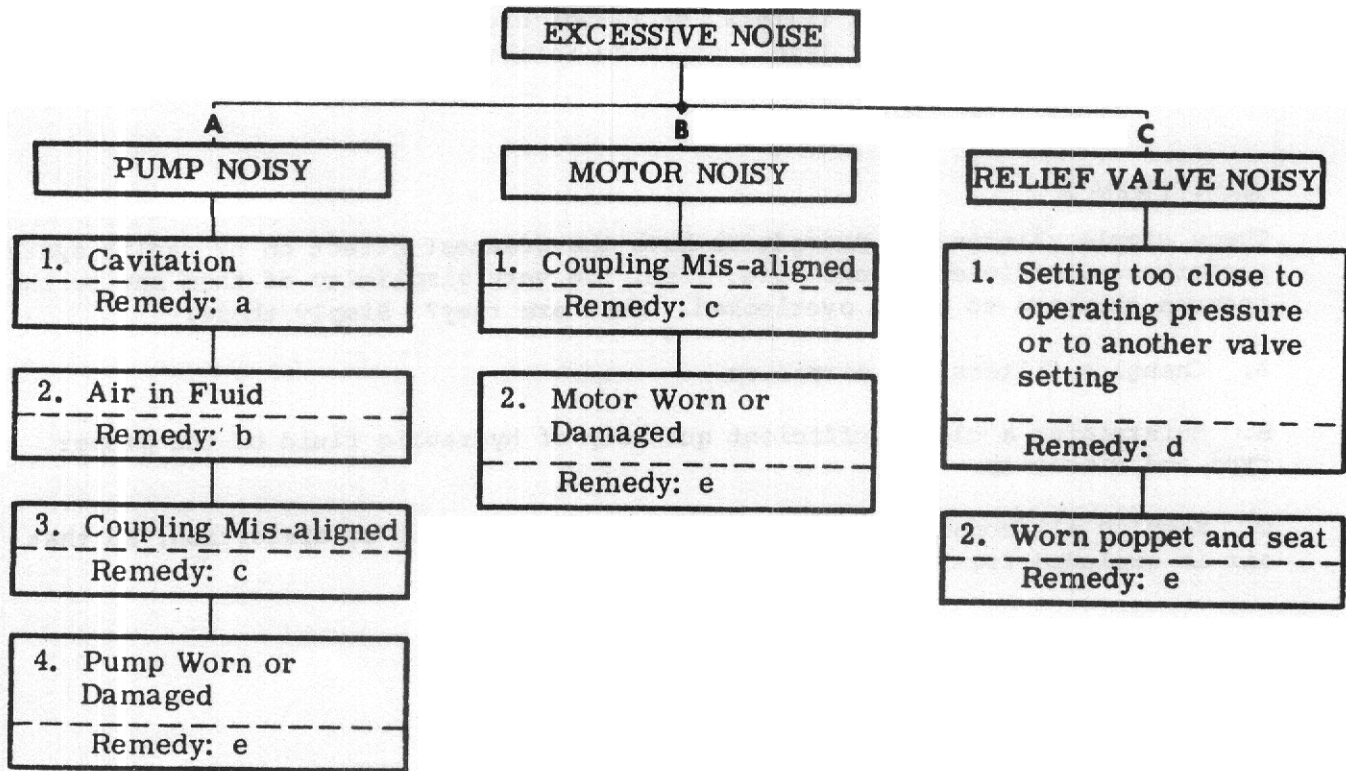
Three simple maintenance procedures have the greatest effect on hydraulic system performance, efficiency, and life. Yet, the very simplicity of them may be the reasons they are so often overlooked. What are they? Simply these:

- A. Changing filters and strainers.
- B. Maintaining a clean sufficient quantity of hydraulic fluid of the proper type and viscosity.
- C. Keeping all connections tight, but not to the point of distortion, so that air is excluded from the system.



The following charts are arranged in five main categories. The heading of each one is an effect which indicates a malfunction in the system. For example, if a pump is exceptionally noisy, refer to Chart I titled EXCESSIVE NOISE. The noisy pump appears in Column A under the main heading. In Column A there are four probable causes for a noisy pump. The causes are sequenced according to the likelihood of happening or the ease of checking it. The first cause is cavitation and the remedy is "a". If the first cause does not exist, check for cause number 2, etc.

1



Remedies:

- a. Any or all of the following: Replace dirty filters - Clean clogged inlet line - Clean reservoir breather vent - Change system fluid - Change to proper pump drive motor speed - Overhaul or replace supercharge pump.
- b. Any or all of the following: Tighten leaky inlet connections - Fill reservoir to proper level (with rare exception all return lines should be below fluid level in reservoir) - Bleed air from system - Replace pump shaft seal.
- c. Align unit and check condition of seals and bearings.
- d. Install pressure gauge and adjust to correct pressure.
- e. Overhaul or replace.

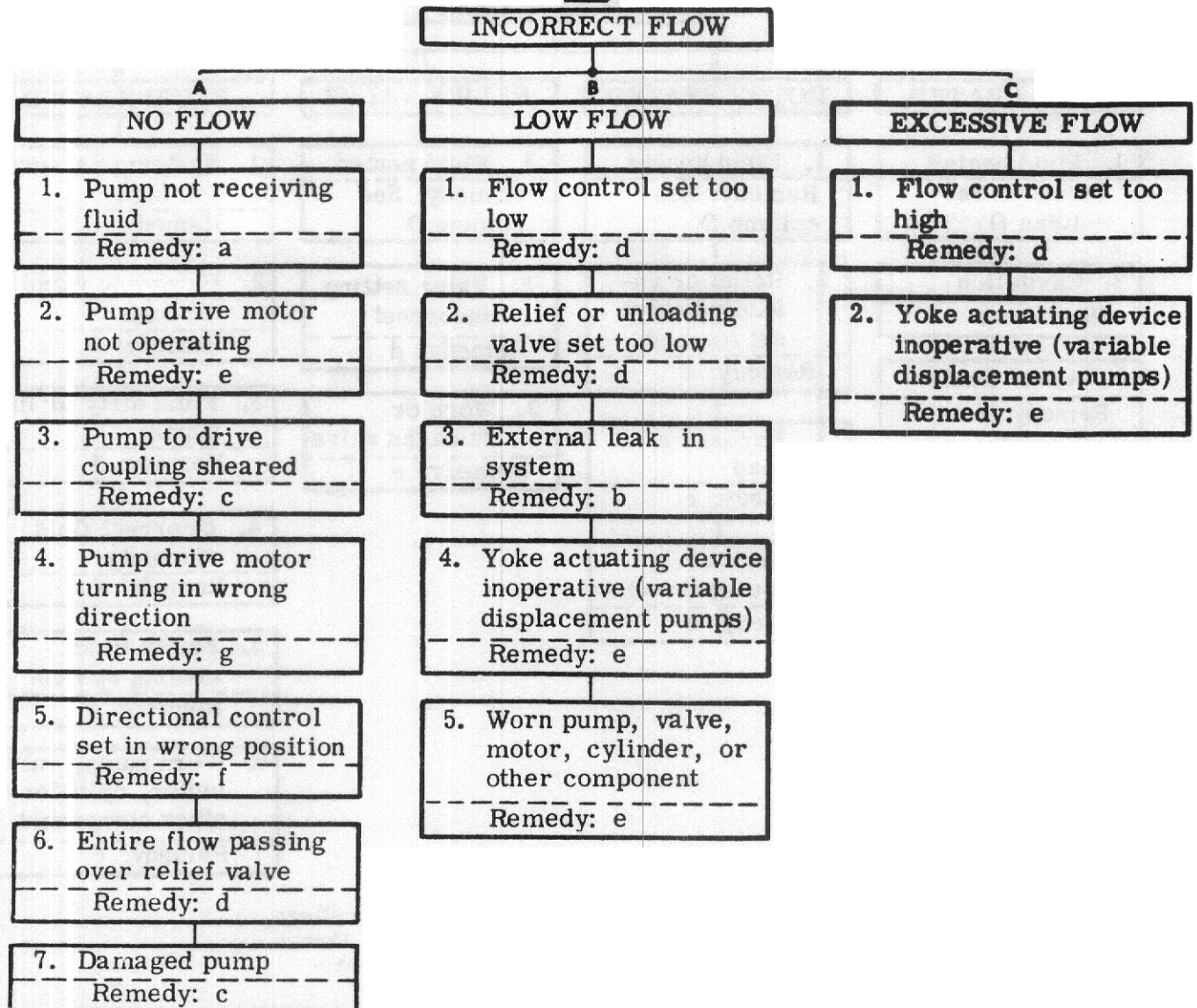


EXCESSIVE HEAT

A	B	C	D
PUMP HEATED	MOTOR HEATED	RELIEF VALVE	FLUID HEATED
1. Fluid heated Remedy: See column D	1. Fluid heated Remedy: See column D	1. Fluid heated Remedy: See column D	1. System pressure too high Remedy: d
2. Cavitation Remedy: a	2. Relief or unloading valve set too high Remedy: d	2. Valve setting incorrect Remedy: d	2. Unloading valve set too high Remedy: d
3. Air in fluid Remedy: b	3. Excessive load Remedy: c	3. Worn or damaged valve Remedy: e	3. Fluid dirty or low supply Remedy: f
4. Relief or unloading valve set too high Remedy: d	4. Worn or damaged motor Remedy: e		4. Incorrect fluid viscosity Remedy: f
5. Excessive load Remedy: c			5. Faulty fluid cooling system Remedy: e
6. Worn or damaged pump Remedy: e			6. Worn pump, valve, motor, cylinder or other component Remedy: e

Remedies:

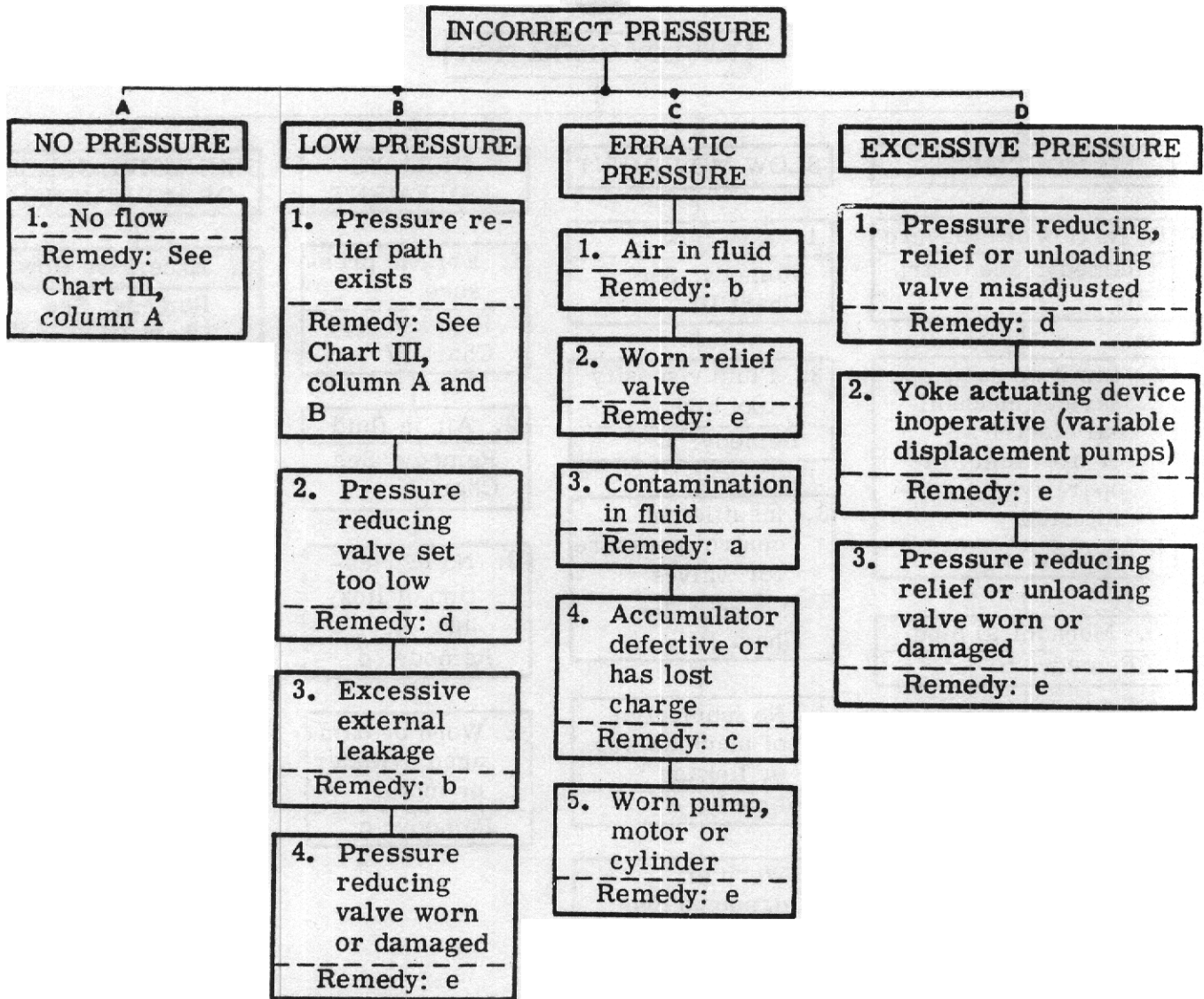
- Any or all of the following: Replace dirty filters - Clean clogged inlet line - Clean reservoir breather vent - Change system fluid - Change to proper pump drive motor speed - Overhaul or replace supercharge pump.
- Any or all of the following: Tighten leaky inlet connections - Fill reservoir to proper level (with rare exception all return lines should be below fluid level in reservoir) - Bleed air from system - Replace pump shaft seal.
- Align unit and check condition of seals and bearings - Locate and correct mechanical binding - Check for work load in excess of circuit design.
- Install pressure gauge and adjust to correct pressure.
- Overhaul or replace.
- Change filters and also system fluid if of improper viscosity - Fill reservoir to proper level.



Remedies:

- a. Any or all of the following: Replace dirty filters - Clean clogged inlet line - Clean reservoir breather vent - Fill reservoir to proper level - Overhaul or replace supercharge pump.
- b. Tighten leaky connections - Bleed air from system.
- c. Check for damaged pump or pump drive - Replace and align coupling.
- d. Adjust.
- e. Overhaul or replace.
- f. Check position of manually operated controls - Check electrical circuit on solenoid operated controls.
- g. Reverse rotation.

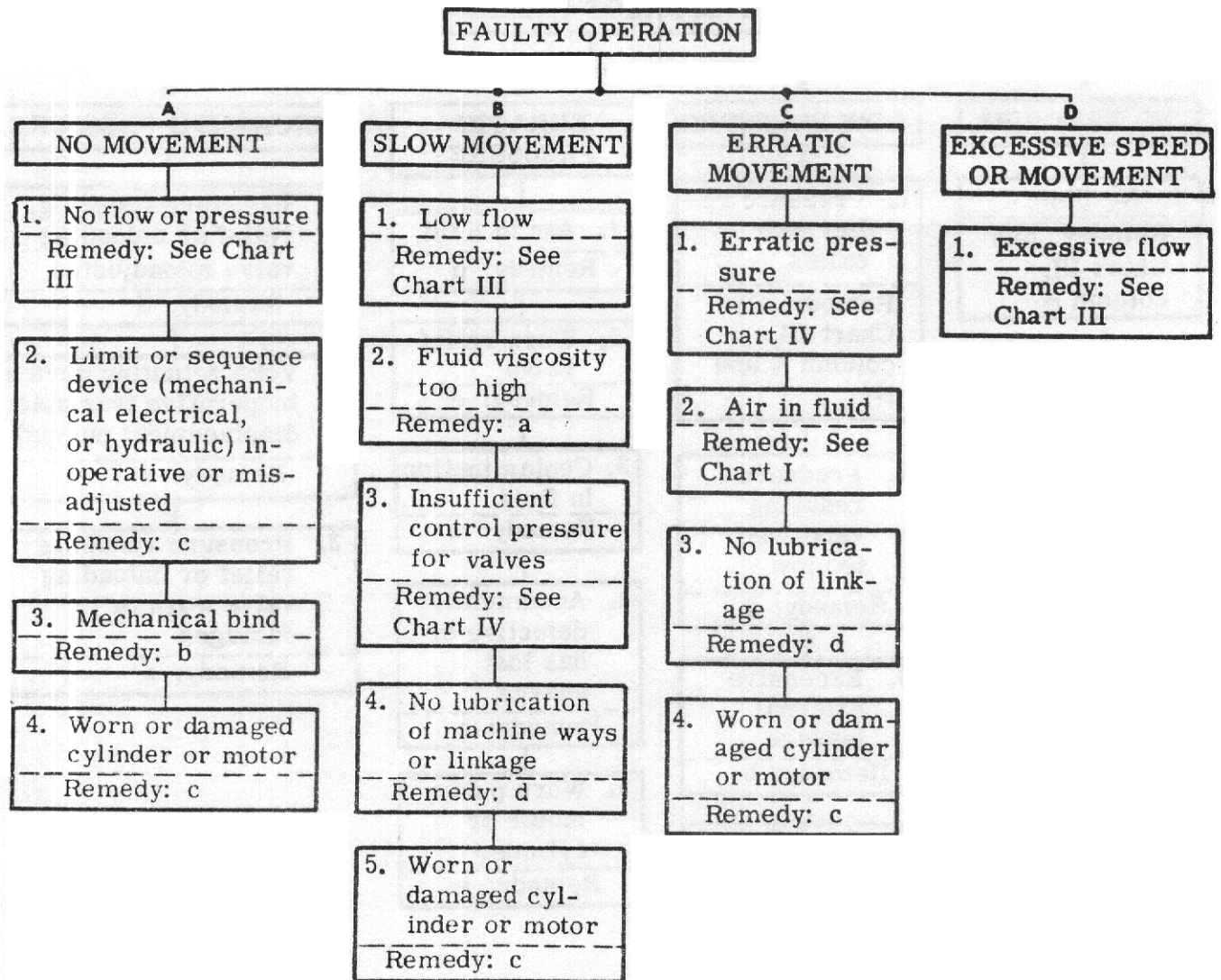
4



Remedies:

- a. Replace dirty filters and system fluid.
- b. Tighten leaky connections (fill reservoir to proper level and bleed air from system).
- c. Check gas valve for leakage - Charge to correct pressure - Overhaul if defective.
- d. Adjust.
- e. Overhaul or replace.

5



Remedies:

- a. Fluid may be too cold or should be changed to clean fluid of correct viscosity.
- b. Locate bind and repair.
- c. Overhaul or replace.
- d. Lubricate.

Quality Hydraulic Fluids

Today's hydraulic fluid has to be tougher, to provide peak pressure and instant power through many hours of constant operation. It must stand up day after day in all types of systems. It has to be ready-to-go on cold winter mornings and not let down on hot summer afternoons. This means more oil punishment and need for built-in quality.

Quality Hydraulic Fluid Needs:

- Anti-wear properties to prevent scuffing and excessive wear at high speeds, also high-pressure operations.
- High stability to resist oxidation, prevent varnish formation and deposits that foul systems.
- Rust resistant additives to prevent rust formation from moisture condensation.
- Anti-foam agents to break up air bubbles in the fluid and prevent "foaming" that cause sluggish, erratic operations.
- Good viscosity index for easy flow at low temperatures without thinning out at high temperatures after hours of use.
- Seal conditioner properties to prevent cracking or excessive swelling of seal that can result in fluid leaks.

The need for good quality hydraulic fluid is very important in today's hard working vehicles. In today's modern systems just any hydraulic fluid won't do, the wrong fluid is a sure road to trouble. Always make sure that the hydraulic fluid you use meets or exceeds vehicle manufacture's specification.

Oil Storage & Handling

Refiners of hydraulic oils take particular care to prevent contamination of any sort from entering the oil up to the time of delivery. It is just as important to exercise care in preventing contamination from entering after its delivery, during storage and handling.

Following these procedure is absolutely necessary to the proper operation of any hydraulic system or component.

Storage:

- Select a clean, dry spot.
- Store the drums on there sides.
- Cover the drums to prevent dust accumulation.
- Keep water form collecting on the top of the drum. Water can seep through the plug and into the oil.
- Avoid condensation in storage; drums must be protected from sudden temperature change.

Handling:

- Before opening a drum, wipe the top carefully to prevent dirt from falling into the oil. If by chance dirt gets into the oil make sure to strain the oil by using a 100-mesh screen. If available filter or centrifuge the oil, it is important to know that active earth type filters remove oil additives. Consult with your oil manufacturer for the correct filter.
- When drawing oil out of storage make sure to use a clean approved labeled container. If oil must be transported or stored in the container keep it tightly covered.

Filling:

- Before removing the filler cap, wipe off plug or cap with a lint-free cloth.
- “Recommend” use a 10-micron filter or filtered nozzle on the container when pouring oil from a container into a reservoir.
- The reservoir should be tightly covered after filling the system.
- The container should be covered and stored in a clean place.

Dust, water lint or contaminations of any kind can seriously damage the operation of the hydraulic system. Following the above-mentioned procedures can help prevent contaminating material from entering hydraulic system.

Hydraulic Fitting Tightening Procedure

1. Tighten fitting finger-tight until it stops turning, while moving the fitting lightly side to side to prevent cocking or thread damage.
2. Lightly snug fitting with a wrench until it bottoms out on the seat or port. Do not over tighten.

F-Series Mast Assembly

IMPORTANT

Before removing any component for overhaul, make sure the correct repair parts and/or kits are available.



WARNING

An upright or carriage can move unexpectedly.

- Do not walk or stand under raised forks.
- Keep clear of load and carriage when making any check or adjustment.
- Keep your arms and fingers away from moving parts of the upright.
- Block the carriage or upright when working with the components in a raised position.
- Do not reach through open areas of the upright.
- Never attempt to move or align the rails by hand. Use a prybar.

Failure to follow these warnings can result in serious injury.



WARNING

Use an approved safety platform to reach the upper areas of the upright. Never use the upright as a ladder.

Service Intervals

- All upright components should be visually checked every day during the Operator's Daily Inspection.
- A thorough visual inspection should be performed by a trained service professional every 50-250 hours.
- Lift chains should be inspected and lubricated every 50-250 hours or monthly.
- Lift chain tension should be checked every 50-250 hours or monthly.
- Upright and carriage roller checks should be performed every 50-250 hours or monthly.
- Roller patterns should be checked every 6 months or after 1000 hours of service.
- Racking and drift tests should be performed every 50-250 hours or monthly.
- The complete extended inspection should be performed at least every year or 2000 hours of operation.

Description

The upright assembly includes the lift chains, free lift cylinders, carriage, forks, and upright or rails sets. Each of the components can be serviced using the tests, checks, adjustments, removal, and replacement procedures in the following Sections.

The upright uses the hydraulic cylinders and chain sets to lift the carriage and rail sets. On standard, two-stage uprights, the free lift cylinders lift the carriage with the chains and directly lift the inner rail sets. On triple stage-uprights, the free lift cylinder lifts the carriage by the chains. When the free lift reaches its maximum extension, fluid is diverted to the rail lift cylinders, which lifts the inner rails using a second set of chain, and lifts the intermediate rails by direct lift.

Friction and play between the nesting rails is controlled by roller sets mounted on the rails carriage. When rails or rollers become worn, the gap between the rollers and rails becomes larger, creating more play in lifting and lowering operations. The rail-web-to-roller-side clearances

can be reduced by shimming the rollers to close the gap between the roller and rails.

Forks use a hanger design for mounting on the carriage. Auxiliary attachments may be added to the upright for specialized handling operations. To operate the attachment, the hydraulic circuit is modified with a hose adaptation kit, and an auxiliary section is added to the main hydraulic valve.

The free lift and rail lift cylinders on standard uprights and triple-stage uprights (TSUs) may be either piston or ram type cylinder. The free lift cylinder on TSUs is a piston type cylinder. See chart under "specifications" to determine the type of cylinder used on the upright you are servicing.

Piston-type cylinders contain a bypass check valve in the piston that allow any fluid that has accumulated in the rod end of the cylinder to return to the system. The check valve can be removed and cleaned if indicated by troubleshooting. A velocity fuse in the hydraulic port of the free lift cylinders prevents the mast from falling rapidly in case of sudden fluid pressure loss due to line breaks.

The main pump sends fluid to the main hydraulic control valve, which contains spools that route fluid to the lift cylinders and tilt cylinders. The valve assembly also contains counter-balance valve the prevents upright tilt when the truck is not operating.

Fluid flow rates for lift functions are factory-set and not adjustable. Flow rates for tilt and auxiliary functions are controlled by changing the flow cartridges on the main hydraulic valve. A non-adjustable "load-lowering" flow valve mounted on the upright limits upright lowering speed.

Tilt Check and Adjustment

NOTE

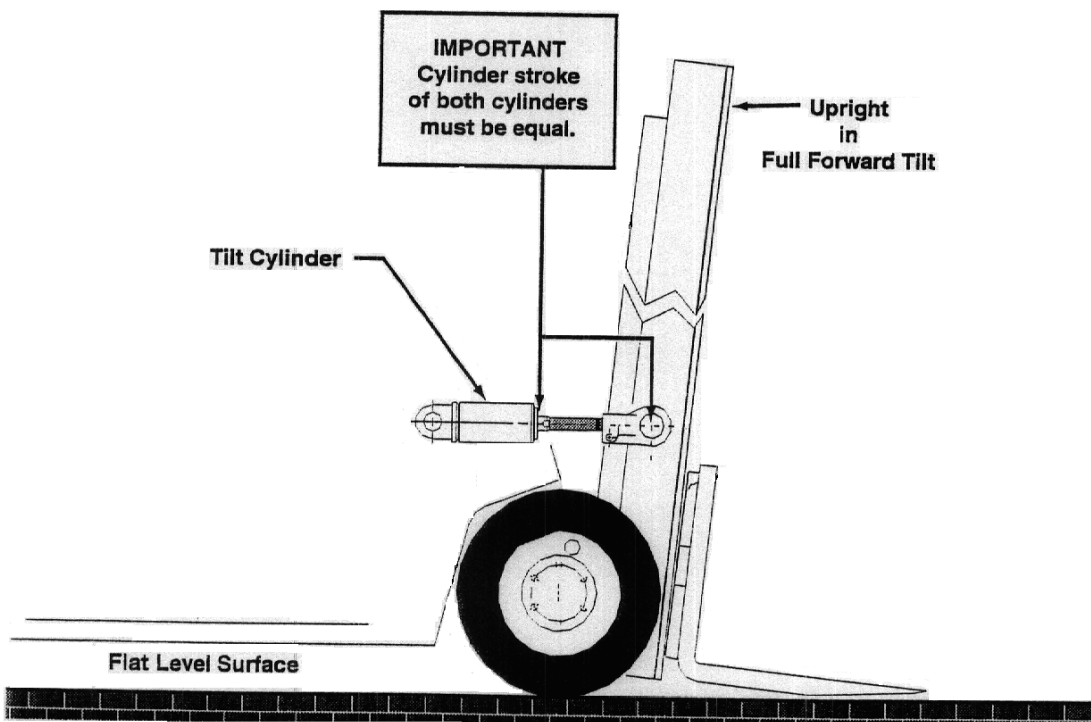
Forward tilt cylinder adjustment must be made before making the backward tilt adjustment.

1. Raise the upright only to the height that will allow the fork tips to clear the floor by a small amount when tilted fully forward.
2. Starting from vertical position, slowly tilt upright forward watching for any "racking" or "twisting" motion as the upright moves to the end of its travel.

IMPORTANT

If upright racks or twists, this indicates unequal stroke of the tilt cylinder rods. The rod length of one cylinder is longer than the other. To correct this condition, shorten the longer cylinder rod.

3. To shorten the cylinder stroke, loosen the clamping fastener on the rod end. Rotate the piston rod clockwise, screwing the rod inward into the threads of the rod end. Tighten clamping fastener when finished.
4. Slowly move upright to the full back tilt position. Check to see if the tilt cylinders "bottom out" (stop) at the same time as the upright reaches the full back tilt position. If they do not, a backward tilt adjustment must be made.
5. Move upright to the vertical position.
6. Slowly tilt the upright backward until one of the cylinders "bottoms out" against its rod spacer or the cylinder gland.
7. Install rod shims to fill in space between rod end and spacer or the gland of the other tilt cylinder. Do not exceed six shims per side.
8. Check adjustment. Move upright to the full forward and back tilt positions. If racking or twisting is still present, adjust as required.



Tilt Cylinder Drift Test

Test Load

- Make a capacity test load. Refer to the data plate on you truck for maximum truck capacity.

NOTE

Be certain the load is evenly distributed on the forks. If the load is a stacked load, it must be stacked to provide maximum stability.

Pick Up Test Load

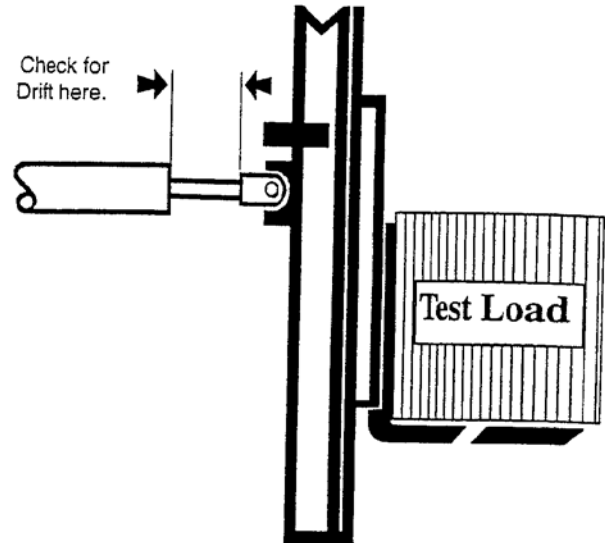
- Adjust forks as wide as possible to provide even distribution of weight.
- Inch forward until the forks completely engage the load.
- Elevate carriage and load approximately 10 to 15 inches.
- Tilt upright to the full back tilt position.
- Shut engine down.
- Apply parking brake.

Cylinder Drift Specifications

The tilt cylinders should not drift more than 1/2 to 3/4 of an inch (12.7 to 19 mm) in a five (5) minute period.

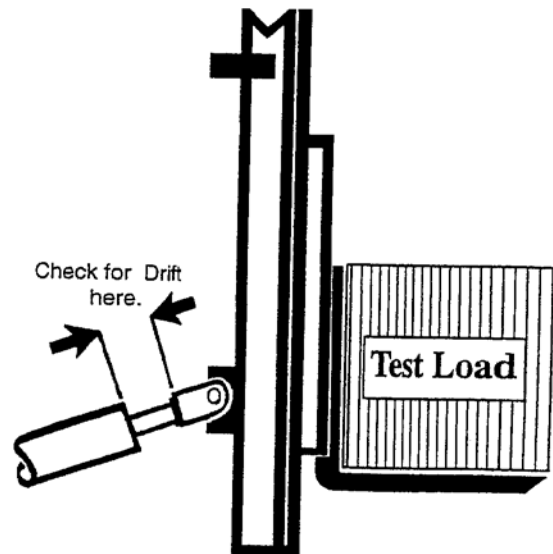
To Measure Cylinder Drift

- Measure the distance between the cylinder gland and the back of the rod end. Record this measurement.
- After five minutes has elapsed, measure the distance between the tilt cylinder and the rod end. If measurement exceeds the above limits, report condition to designated authority.



- Elevate Load 10 - 15 in. (12.7 - 19 mm)
- Place Upright in Full BackTilt.

Hi-Tilt Models

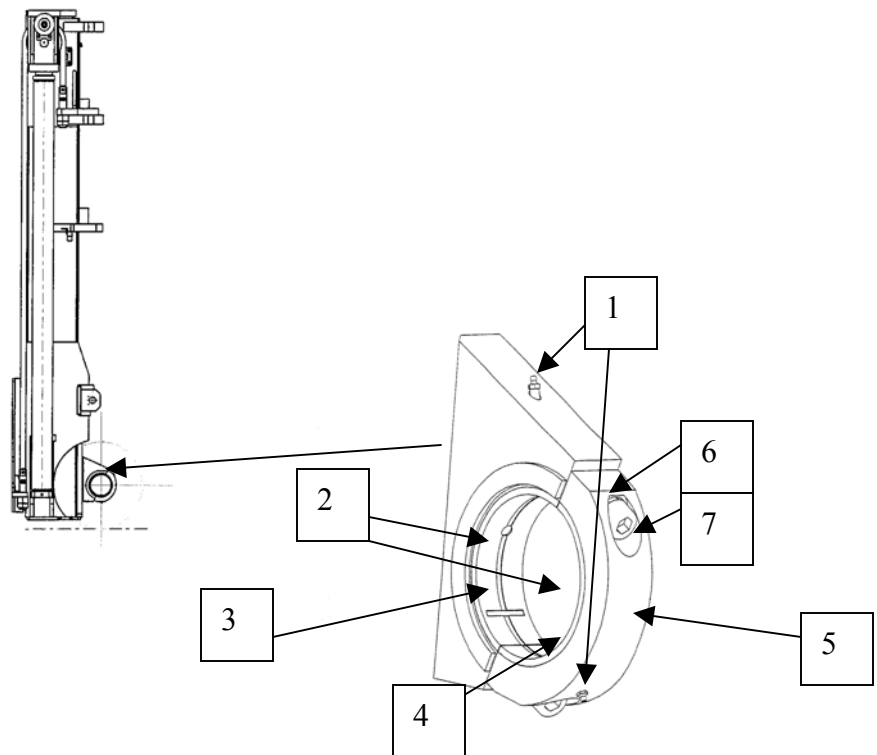


- Elevate Load 10 - 15 in. (12.7 - 19mm)
- Place Upright in Full BackTilt.

Lo-Tilt Models

Mast Hinge Bearing Bolt Locations and Maintenance Procedures

The Mast Hinge Bearing is a load bearing assembly that is a part of the mast that pivots on the two-machined surfaces of the drive axle. There are two hinge bearing right and left assemblies on the mast. Two socket head cap screws item (7) with high collar lock washers item (6) are used to mount the hinge-bearing cap item (5) to the hinge bearing assembly. **NOTE FKS Series model used (1-8"x3.5" SHCS socket head cap screws with nylon patch) with 1" High Collar Lock Washers. F Series model used (M24x100x60mm SHCS) with 24mm High Collar Lock Washer.** There are two brass dowel pins item (2) that retain the upper and lower bearings in the proper position. The hinge bearings are lubricated through the two lube fittings item (1) using a grease gun. **NOTE it is very important that the hinge bearings are lubricated during every PM using good quality grease to prevent damage to the hinge bearings and drive axle.** The upper hinge bearing item (3) supports the mast weight and load weight. The lower hinge bearing item (4) and cap item (5) retains the bearing and mast in its proper location. Due to bearing wear, lack of lubrication, vibrations and other variables from material handling operations, hinge-bearing bolts can come loose and fall out. When doing preventive maintenance every 500hrs it is important that the torque of the hinge bearing bolts be checked.



Checking the Hinge Bearing Cap Screws

It is very important that the torque of the mast hinge bearing cap screws be checked every 500hrs. Failing to do so can result in lost of the hinge bearing cap, cap screw and hinge bearings plus damages to the mast and drive axle.

To gain access to the cap screws it may be necessary to raise the truck up and remove the drive tires.

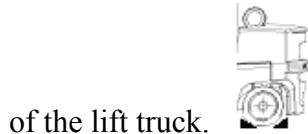
WARNING!

Lifting or jacking any large piece of equipment such as a fork truck presents obvious hazards. It must be done with great care and forethought. Consult the truck weight information that can be found on the trucks data plate specification, to ensure that your lifting equipment is of adequate capacity.

WARNING!

Defective equipment can cause accidents! All tools and lifting equipment must be in good condition. Meet the load requirements and have OSHA labels when required. Tools with defects can fail and causing severe injury or death.

1. Put blocks on each side (front and back) of the steering tires to prevent movement



2. Put the mast in a vertical position. Put a block under each outer mast channel.

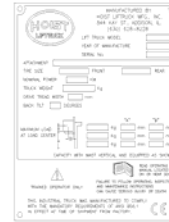


3. Tilt the mast fully forward until the drive tires are raised from the surface.



4. Put additional blocks under the frame behind the drive tires.
5. Tilt the mast back until the weight is off the blocks of the outer mast channel.
6. The drive tires may be removed if necessary to gain additional clearance

7. If the hydraulic system will not operate, use a hydraulic jack under the side of the frame near the front. Make sure that the jack has a capacity equal to at least half the weight of the lift truck. See the nameplate.



8. **NOTE:** Some lift trucks have lifting eyes. These lift points can be used to raise the lift truck with a crane so that blocks can be installed.
9. For the FKS models with 1-8"x3.5" torque 545 Ft-lbs, Check the cap screws with a 3/4" Allen Socket and Torque Wrench.
10. For the F Series models with M24x100x60mm torque 585 Ft-lbs, Check the cap screws with a 19mm Allen Socket and Torque Wrench.

Removal and Installation Hinge Bearing Cap and Screw

1. Make sure that the area of both hinge bearing cap, mating surface and related parts is clean free of dirt and grease.
2. Inspect the cap, mating surface and bearing for imperfections, pay close attention to the corners, dress the surfaces with a file if necessary to remove dings. Replace Hinge Bearing if necessary. **Note consult your Hoist Service if there is excessive wear or damages.**
3. Clean the threads of the screw and hinge bearing using low-pressure air and a degreaser. **Note wear safety goggles and gloves.**
4. Apply Loctite 271 Tread Locker to the surface of the bolt thread.
5. For the FKS models Install the cap and screws, install the screws using a 3/4" Allen Socket and Socket Wench with equal amounts turns until the cap is seated with no gaps.
6. For the F Series models Install the cap and screws, install the screws using a 19mm Allen Socket and Socket Wench with equal amounts turns until the cap is seated with no gaps.
7. For the FKS models Torque the bolts equally to 545 Ft-lbs **Note consult your Hoist Service if there is gaps between the cap and mating surface**
8. For the F Series models Torque the bolts equally to 585 Ft-lbs **Note consult your Hoist Service if there is gaps between the cap and mating surface**

NOTE: ALWAYS USE HOIST APPROVED REPLACEMENT PARTS

FKS Mast Service Instructions

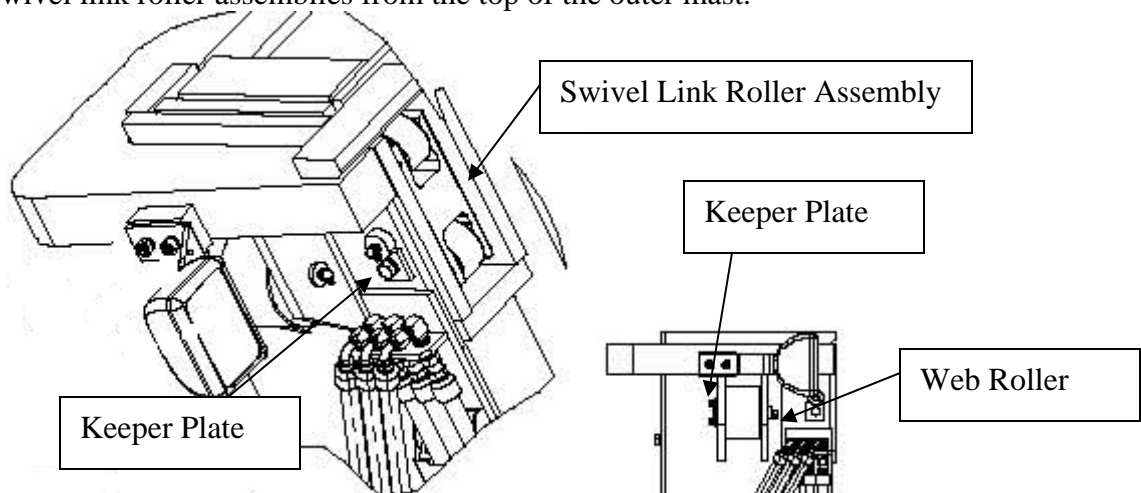
The mast on the fks truck can be disassembled on the truck with the use of an overhead crane or a lift truck with adequate lifting capacity.

Warning! Lifting or jacking any large piece of equipment such as a fork truck presents obvious hazards. It must be done with great care and forethought. Consult the truck weight information that can be found on the data plate specification, to ensure that your lifting equipment is of adequate capacity.

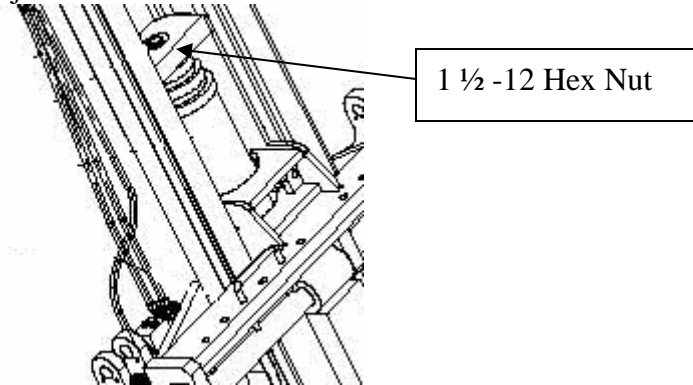
Warning! Defective equipment can cause accidents! All tools and lifting equipment must be in good condition. Meet the load requirements and have OSHA labels when required. Tools with defects can fail and cause severe injury or death.

To service the carriage or inner channel the assemblies must be removed from the outer mast channel. The carriage is removed from the bottom of the inner channel assembly. To perform the services to rollers, pins and make other repairs use the following instructions. Note: If the mast assembly is removed from the truck face the carriage up.

- Remove forks or any attachments and fully lower the carriage.
- Remove all keeper plates that retain the pins for the two web rollers and two swivel link roller assemblies from the top of the outer mast.



- Remove the large center 1 ½ hex nut from the top of the apron carriage. Secure the lift cylinder with a jack or blocks if mast is removed from truck and work is

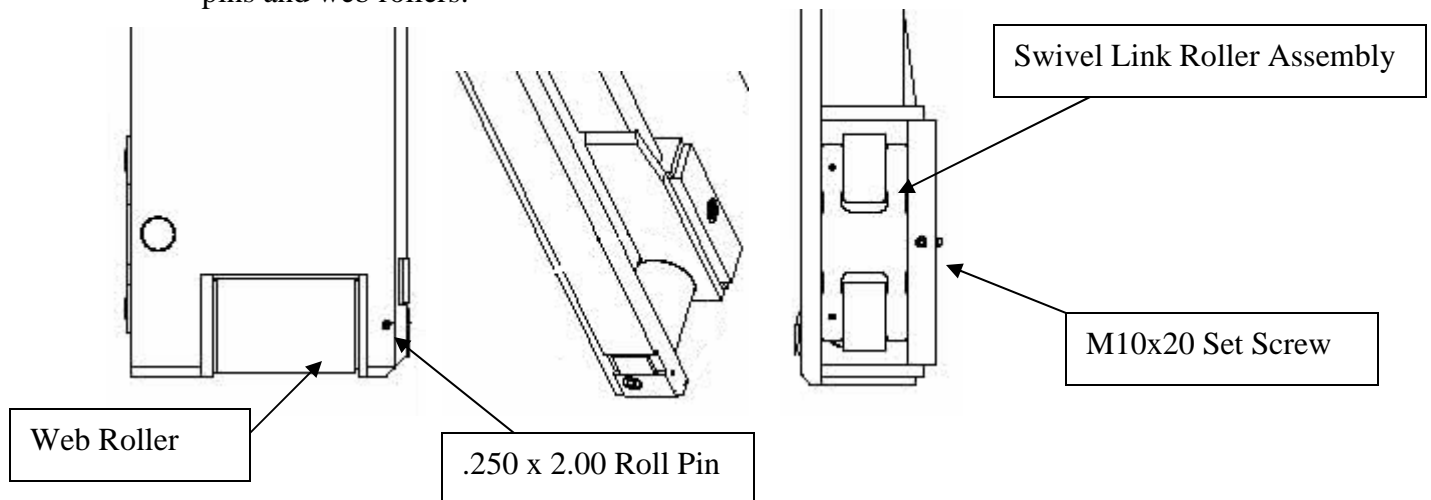


done on the floor.

- The inner channel and carriage can now be lifted out from the outer channel.

To remove the carriage from the inner channel lay the assembly on the floor with the carriage facing up.

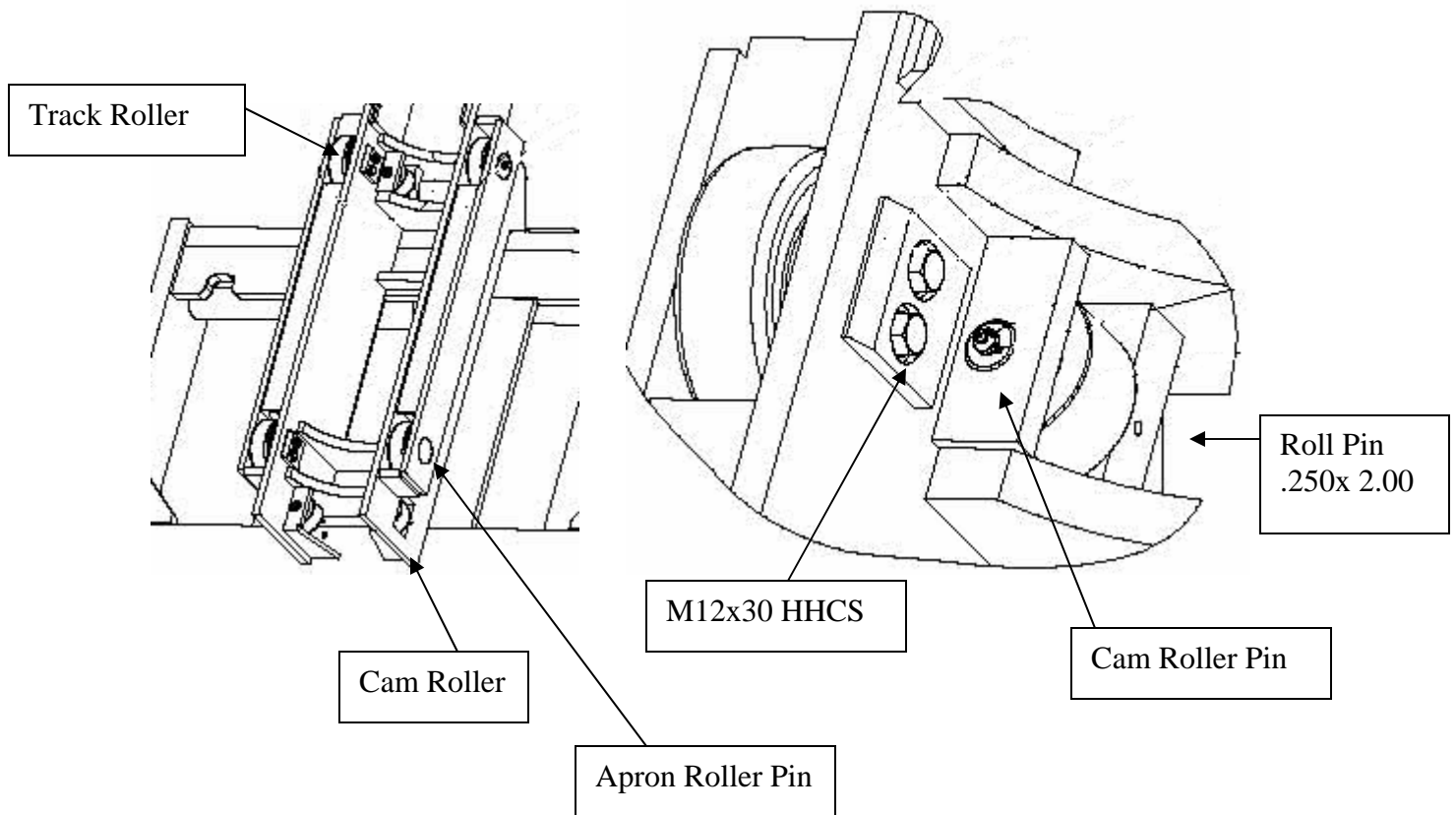
- Remove the M10x12 socket set screws that retain the pins from the two swivel links. Remove the pins and swivel link assemblies.
- Remove the two .250 x 2.00 roll pin that retain the two web rollers. Remove the pins and web rollers.



The carriage now can be removed from the bottom of the inner channel.

Removing the track rollers from the apron carriage:

- Loosen the two M12x30 HHCS about 2 to 3 turns and lightly tap on the screws to pop loose the apron roller pin shaft.
- Remove the two M12x30 HHCS and remove the apron roller pin.



Removing the cam rollers from the apron carriage:

- Using a .250 punch knock the roll pin out from the apron carriage.
- Knock the pin out using the access holes in the front of the apron carriage and remove the cam roller pin.

ENVIRONMENTAL CONDITIONS

Environments in which material handling and lifting mechanisms operate can vary widely, from outdoor moisture to mildly corrosive or highly corrosive industrial atmospheres, in addition to abrasive exposures such as sand and grit. Some effects can be as follows:

Moisture -- Corrosive rusting reduces chain strength by pitting and cracking.

Temperature -- Low temperature reduces chain strength by embrittlement. Going in and out of cold storage results in moisture from condensation.

Chemical Solutions or Vapors -- Corrosive attack on the chain components and/or the mechanical connections between the chain components. Cracking can be (and often is) microscopic. Propagation to complete failure can be either abrupt or may require an extended period of time.

Abrasives -- Accelerated wearing and scoring of the articulating members of the chain (pins and plates), with a corresponding reduction in chain strength. Due to the inaccessibility of the bearing surfaces (pin surfaces and plate apertures), wear and scoring are not readily noticeable to the naked eye.

Each specific application should be evaluated, based on the degree of exposure and the areas of possible operation. A chain replacement schedule should be established to prevent chain failure. This schedule can be established by frequent inspection. Based on the observations, the frequency of inspection can be changed. This inspection procedure development should go on until a projected time of replacement can be predicted. A chain by its very nature and exposure should be considered an expendable item and a safe chain replacement schedule established.

It is further recommended that chains used in cold stores exposed to very low temperatures, or chains used in corrosive atmospheres, receive frequent, very thorough inspections until such time as a reliable replacement cycle has been determined.

DYNAMIC IMPULSE/SHOCK LOADS

Following are some examples of dynamic shock loading which can impose abnormal loads above the endurance limit of leaf chain:

High velocity movement of load, followed by sudden, abrupt stops.

Carrying loads in suspension over irregular surfaces such as railroad tracks, potholes, and rough terrain.

Attempting to "inch" loads which are beyond the rated capacity of the handling or lifting mechanism.

The above load cycles and environmental conditions make it impossible to predict chain life. It is therefore necessary to conduct frequent inspections until replacement life can be predicted.

Chain Lubrication

Like all bearing surfaces, the precision-manufactured, hardened-steel, joint-wearing surfaces of leaf chain require a film of oil between all mating parts to prevent accelerated wear.

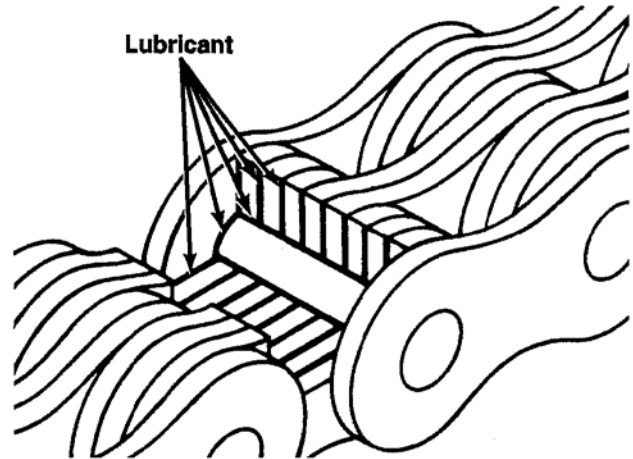
Use Chain and Cable Lube for lubrication of chains.

Maintaining a lubricant film on all chain surfaces will:

- Minimize joint wear.
- Improve corrosion resistance.
- Reduce the possibility of pin turning.
- Minimize tight joints.
- Promote smooth, quiet chain action.
- Lower chain tension by reducing internal friction in the chain system.

Laboratory wear tests show #40 oil to have a greater ability to prevent wear than #10 oil. Generally, the heaviest (highest viscosity) oil that will penetrate the joint is best.

Whatever method is used, the oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life.



The frequency of lubrication will vary with the operating conditions and the environment. The best lubrication time is during each P.M. (50-250 hours or four weeks maximum actual truck operating time). Trucks parked outdoors, or in very severe service, may need lubrication more often to keep a layer of oil on all chain surfaces.

To prepare the chain for oiling, brush the leaf chain plates with a stiff brush or wire brush. This will clear the space between the plates so that oil may penetrate the live bearing area.

Oil may be applied with a narrow paint brush or directly poured on. Chain should be well flooded to be sure the oil penetrates the joint.

In difficult to reach locations, use a good quality oil under pressure, such as an aerosol can or pump pressure spray.

Chain Removal and Replacement

WARNING

The procedures for removing and replacing chain sets involve hoisting and blocking components.

- Do not walk or stand under raised forks.
- Keep your arms and fingers away from moving parts of the upright.
- Do not reach through open areas of the upright.

Failure to follow these warnings can result in serious injury.

Periodic Inspections

Each 50-250 hours of operation (more frequently in severe or extreme environments), chains should be inspected and lubricated. Inspection should focus on the following:

Rust and Corrosion

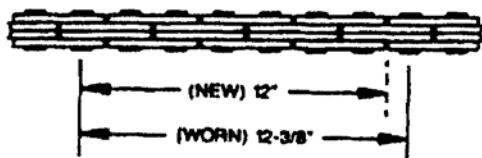
Corrosion will reduce the load-carrying capacity of lift chain because corrosion causes sideplate cracking. Protect lift chains from corrosion whether in service or in storage. The factory lubrication on chains is a very good rust and corrosion inhibitor. The factory lubrication is applied in a hot dip tank to assure complete penetration into the joint. After the chain has been put in service, there must be a layer of oil on the chains at all times. Heavy motor oil is used as a lubricant and a corrosion inhibitor.

During inspection, check for a layer of oil on the external chain surfaces. Under some operating conditions, it will be necessary to lubricate chains between P.M.'s.

Chains with corrosion must be inspected for cracked plates. Outside plates are especially susceptible to stress-corrosion cracking. If chains have heavy rust or corrosion, they must be removed from the upright for a complete inspection for cracked plates. If the plates are cracked, all chains on the truck must be replaced. Lubricate chains when they are installed on the upright.

Elongation

When a length of 305 mm (12.00 in.) of new chain has elongated to a length of 315 mm (12.36 in.), it should be discarded and replaced. Measure the chain in the section that moves over the sheaves; it receives the most frequent articulation. (Measuring the chain near its clevis terminals could give an erroneous reading. It would not have flexed as frequently, if indeed at all, as nearer the middle of the assembly.)

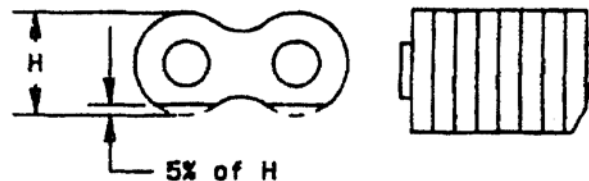


Chains should be replaced when wear exceeds 3% or when 305 mm (12 in.) of chain is stretched 10 mm (3/8 in.).

Do not repair chains by cutting out the worn section and joining a new piece. If part of a chain is worn, replace all the chains on the truck.

Edge Wear

Check the chain for wear on the link plate edges caused by running back and forth over the sheave. The maximum reduction of material should not exceed 5%. This can be compared to a normal link plate height by measuring a portion of chain that does not run over the sheave. Distorted or battered plates on leaf chain can cause tight joints and prevent flexing.

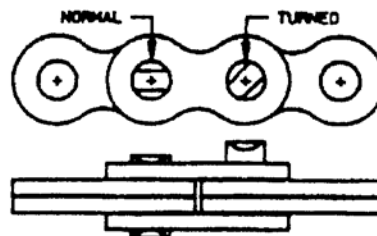


Worn contours and worn surfaces on the outside links or pin heads should not exceed 5% of new link height.

Do not repair chains by cutting out the worn section and joining a new piece. If part of a chain is worn, replace all the chains on the truck.

Turning or Protruding Pins

Highly loaded chain operating with inadequate lubrication can generate abnormal frictional forces between pin and link plates. In extreme instances, the torque could surpass the press fit force between the pins and the outside plates, resulting in pin rotation. When chain is allowed to operate in this condition, a pin, or series of pins, can begin to twist out of a chain, resulting in failure. The pin head rivets should be examined to determine if the "VEE" flats are still in correct alignment. Chain with rotated/displaced heads or abnormal pin protrusion should be replaced immediately. Do not attempt to repair the chain by welding or driving the pin(s) back into the chain. Once the press fit integrity between outside plates and pins has been altered, it cannot be restored. Any wear pattern on the pin heads or the sides of the link plates indicates misalignment in the system. This condition damages the chain and increases frictional loading, and should be corrected.



Cracked Plates

The chains should periodically be inspected very carefully, front and back as well as side to side, for any evidence of cracked plates. If any one crack is discovered, the chain(s) should be replaced. Determine the causes of the crack before installing the new chain so the condition does not repeat itself.

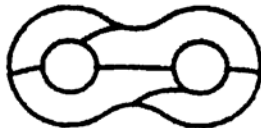
- **Fatigue Cracking** – Fatigue cracks are a result of repeated cyclic loading beyond the chain's endurance limit. The magnitude of the load and frequency of its occurrence are factors which determine when fatigue failure will occur. The loading can be continuous or intermittent (impulse load).



Fatigue cracks generally run from the pin hole toward the edge of the link plate approximately 90° from the line of pull.

Fatigue cracks almost always start at the link plate pin hole (point of highest stress), and are perpendicular to the chain pitch line. They are often microscopic in their early stage. Unlike a pure tensile failure, there is no noticeable yielding (stretch) of the material.

- **Stress-Corrosion Cracking** – The outside link plates, which are heavily press fitted to the pins, are particularly susceptible to stress corrosion cracking. Like fatigue cracks, these initiate at the point of highest stress (pin hole), but tend to extend in an arc-like path between the holes in the pin plate.



Arc-like cracks in plates are a sign of stress corrosion.

More than one crack can often appear on a link plate. In addition to rusting, this condition can be caused by exposure to an acidic or caustic medium or atmosphere.

Stress corrosion is an environmentally-assisted failure. Two conditions must be present: a corrosive agent and static stress. In the chain, static stress is present at the pin hole due to the press fit pin. No

cyclic motion is required, and the plates can crack during idle periods. The reactions of many chemical agents (such as battery acid fumes) with hardened steel can liberate hydrogen, which attacks and weakens the steel grain structure.

For this same reason, never attempt to electroplate a leaf chain or its components. The plating process liberates hydrogen, and hydrogen embrittlement cracks will appear. These are similar in appearance to stress corrosion cracks.

If a plated chain is required, consult Hoist. Plated chains are assembled from modified, individually plated components, which may reduce the chain rating.

- **Corrosion Fatigue** – Corrosion fatigue cracks are very similar (in many cases identical) to normal fatigue cracks in appearance. They generally begin at the pin hole and move perpendicular (90°) to the chain pitch line.

Corrosion fatigue is not the same as stress corrosion. Corrosion fatigue is the combined action of an aggressive (dirty or abusive) environment and a cyclic stress (not a static stress alone, as in stress corrosion).

Ultimate Strength Failure

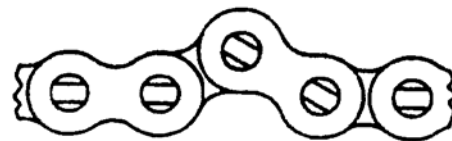
This type of failure is caused by overloads far in excess of the design load.



Broken Plate Caused by Overload

Tight Joints

All joints in leaf chain should flex freely. Tight joints resist flexure and increase internal friction, increasing chain tension required to lift a load. Increased tension accelerates wear and fatigue problems.



If lubrication does not loosen a tight joint, the chain may have corrosion and rust problems or bent pins, and must be replaced.

Lift Chain Replacement

Find the manufacturer's stamped number on the links of the chain. Your Hoist parts dealer will need this number to make sure you get the correct chain. Leaf chain is available in lengths up to 7.65 m (25 ft.). Short sections of leaf chain must never be joined together to form a longer length. Roller and rollerless chain is available in 3.05 m (10 ft.) sections. Never join new chain sections to old chain sections.

Lift chains must always be replaced as pairs. It is impossible to keep a balanced load between chains if a new chain is put into service opposite an old chain. The joints in the old chain may have worn through the hardest layer of the case-hardened pins, and the old chain will wear much faster than the new chain, causing problems keeping chain tension equal. The new chain will wear more slowly, causing it to hold most of the load, resulting in early wear and failure.

Do not remove the lubricant from new chains. The manufacturer's lubricant helps prevent wear and corrosion. If the original factory lubrication has dried or been removed, apply Chain and Cable Lube.

After the old chains have been removed from the upright, very carefully inspect the chain anchors and sheaves. Broken, cracked, or worn anchors must be replaced. Replace worn sheaves and check the sheave bearings for wear.

Do not paint new chain before or after installation. Paint will help prevent corrosion, but will also prevent lubricant from reaching the pin surface for good joint lubrication.

Use new anchor pins when installing new chains. Old pins may contain fatigue cracks that could cause failure. After the chains have been connected to the anchors, adjust the chain tension.

Correct chain installation and upright adjustment will increase chain service life.

Checklist for Lift Chain Maintenance

A. Lift Chain Inspection

Every truck PM (50-250 hours) check for:

1. Cracked plates
2. Rust and corrosion
3. Turned pins
4. Tight joints
5. Wear - measure portion of chain that flexes over sheaves using a steel tape.

B. Lift Chain Lubrication

Every truck PM (50-250 hours), or 50 hrs. in corrosive environment:

1. Apply Chain and Cable Lube
 2. Lubricate full length of all strands.
- C. Lift Chain Replacement
1. All chains must be replaced if any strand has wear of 3% or more, or if any of the conditions listed in Section A are found during inspection.
 2. Order replacement chains from your Hoist parts dealer.
 3. Replace all chains as a set.
 4. Do not remove lubricant from or apply paint to new chains.
 5. Replace anchor pins and worn or broken anchors when installing new chains.
 6. Adjust tension on new chains.

Procedure to Check for Chain Wear

1. Find the pitch of the chain.
 - a. Measure from the center of one chain pin to the center of the next chain pin.
2. Locate the specifications.
 - a. Locate the pitch of the chain.
 - b. Find the number of pins to be counted (span).
 - c. Find the maximum worn length of a selected span.
3. Select an area of chain to be measured.
 - a. Use a section of chain which moves over sheaves.
 - b. Lift a small load.
 - c. Count the number of pins needed for a length measurement.
4. Measure the chain.
 - a. Use a steel tape to measure from the first pin counted to the last pin counted.
 - b. The length measurement must be more than the actual span of the chain section being measured.
 - c. Any chain span which is worn to the length measurement or beyond must be replaced.

Example of the Check for Chain Wear

A mechanic measures from the center of one pin to the center of the next pin and finds the PITCH of the chain to be 25.40 mm (1 in.) After looking at the chain charts, he must align the end of the steel tape with the center of one pin, and count to the thirteenth pin (counting the pin he started with as number one). He measures the length to the center of the thirteenth pin and finds it to be 316.0 mm (12.437 in.) Again, looking at the chart, he finds the maximum worn length to be 314.32 mm (12.375 in.). From this he decides that both chains on this truck must be replaced.

Mast Flaking

It is not uncommon for a new mast to show signs of flaking, leafing, peeling or what appears as some minimal roller gouging. This appearance is indicative of the rollers seating during an initial break-in period and is considered normal. This condition will alleviate itself after a nominal wear-in period. Grease applied to the channel can, and will, retain any particles or flaking and actually serve to properly work harden the surface(s) in question.

Masts are not typically lubricated prior to shipment to prevent contamination of dirt and other debris during transit. When applying grease make sure surfaces are clean and dry and free of any debris. Do NOT use steam or pressure washing to clean the areas to be greased as these processes can contaminate chains and rollers and compromise their internal lubrication. Do NOT apply excessive amounts of grease causing the rollers to slide rather than roll.

To properly access all portions of the rail it may be necessary to extend the mast channels and carriage. Please refer to maintenance manual and observe safe blocking and securing of the mast to prevent injury.



Hoist Mast lube part number M13512 can be purchased from the Hoist parts department.

FORK CALIPER

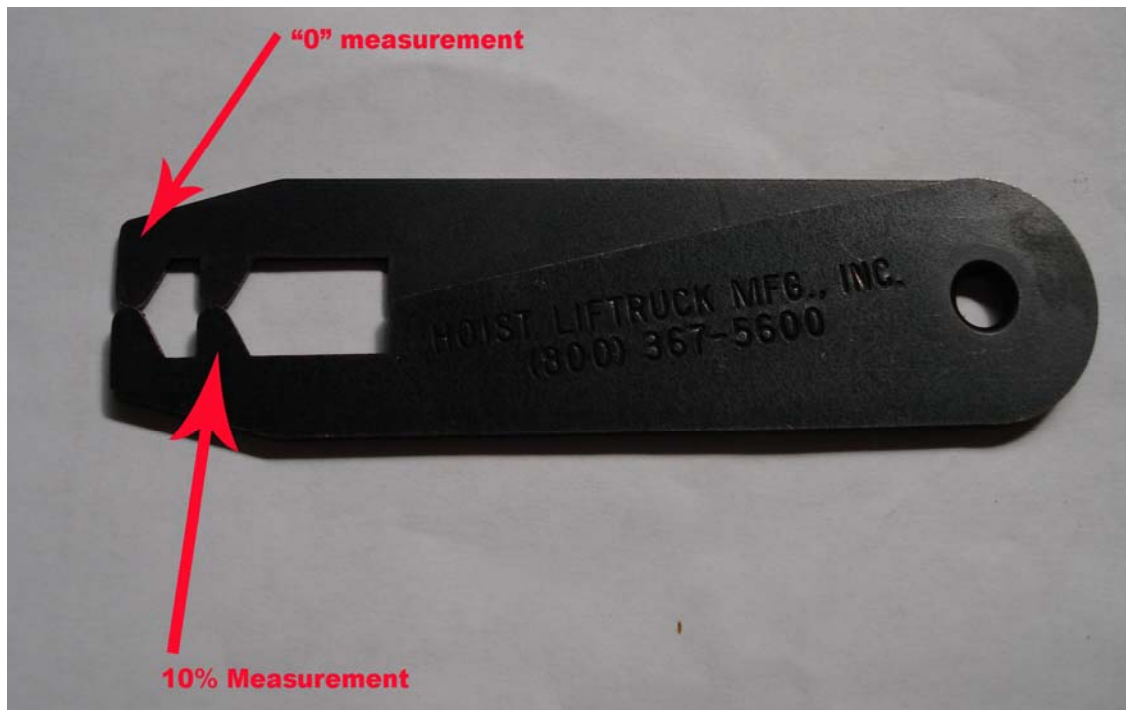
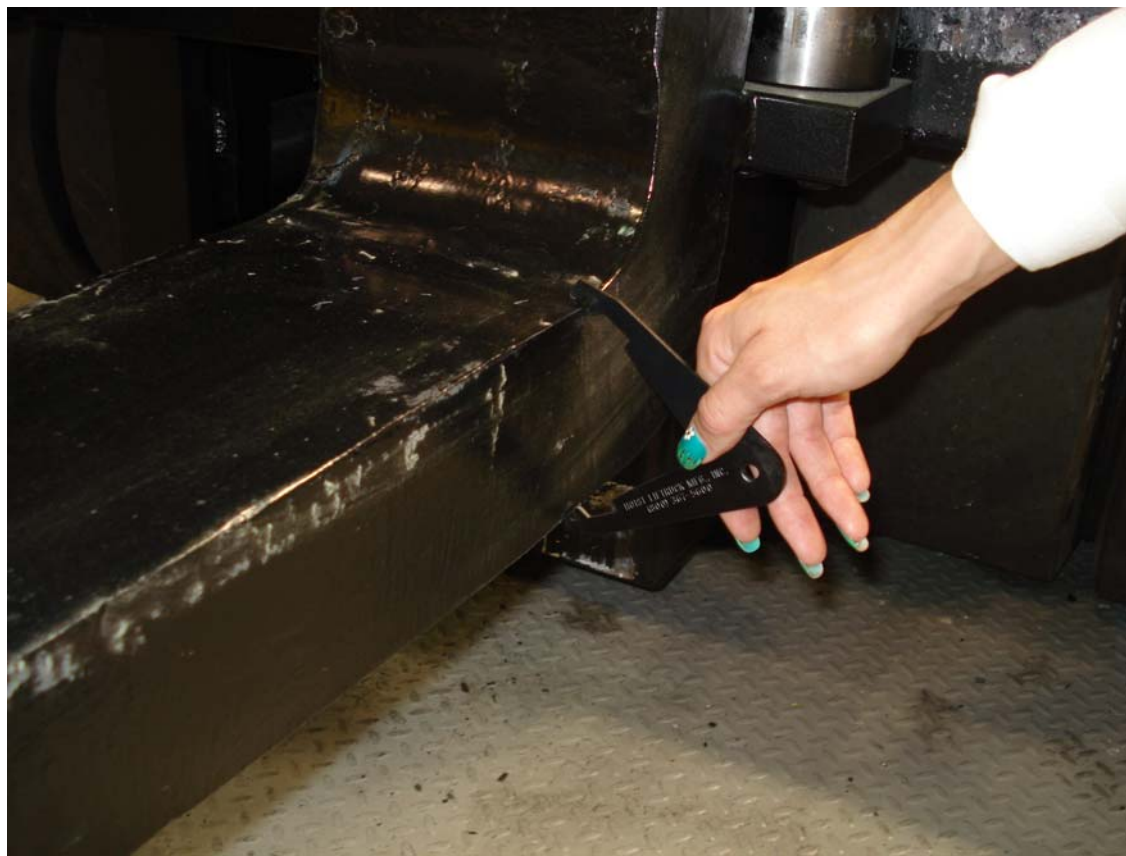


Figure A



Take the fork caliper and measure the upright portion of the fork with the two larger tabs on the caliper. These will be your "0" measurement. *see figure A



Without changing the dimensions of the caliper, measure the bottom portion of the fork, at thinnest point. If the smaller tabs slide over farther on the fork, then you have more than 10% of wear on the heel and the forks should be replaced.

F-Series Lubrication

F SERIES LUBRICATION

This is a list of recommended lubrications always use a good quality equivalent type.

WARNING! ALWAYS USE A CLEAN APPROVED LABEL CONTAINER TO PREVENT CONTAMINATION.

DRIVE AXLE

TYPE 80-90W MIL-L-2105 C or API GL5

HYDRAULIC FLUID

TYPE AW 32

TRANSMISSION “CLARK 32000”

TYPE SAE 30W

CAPACITY 5GAL W/ FILTER “Approximately”

ENGINE GM 5.7

TYPE CITCO 10W30

CAPACITY 5QT W/FILTER

ENGINE COOLANT Use a 50% soft water coolant mixture Note: Do not use more than 50% Antifreeze above –37C (-35F) NEVER: Use more than 68% Antifreeze under any condition.

CHASSIS

TYPE LITHOPLEX RT2 GREASE

MAST

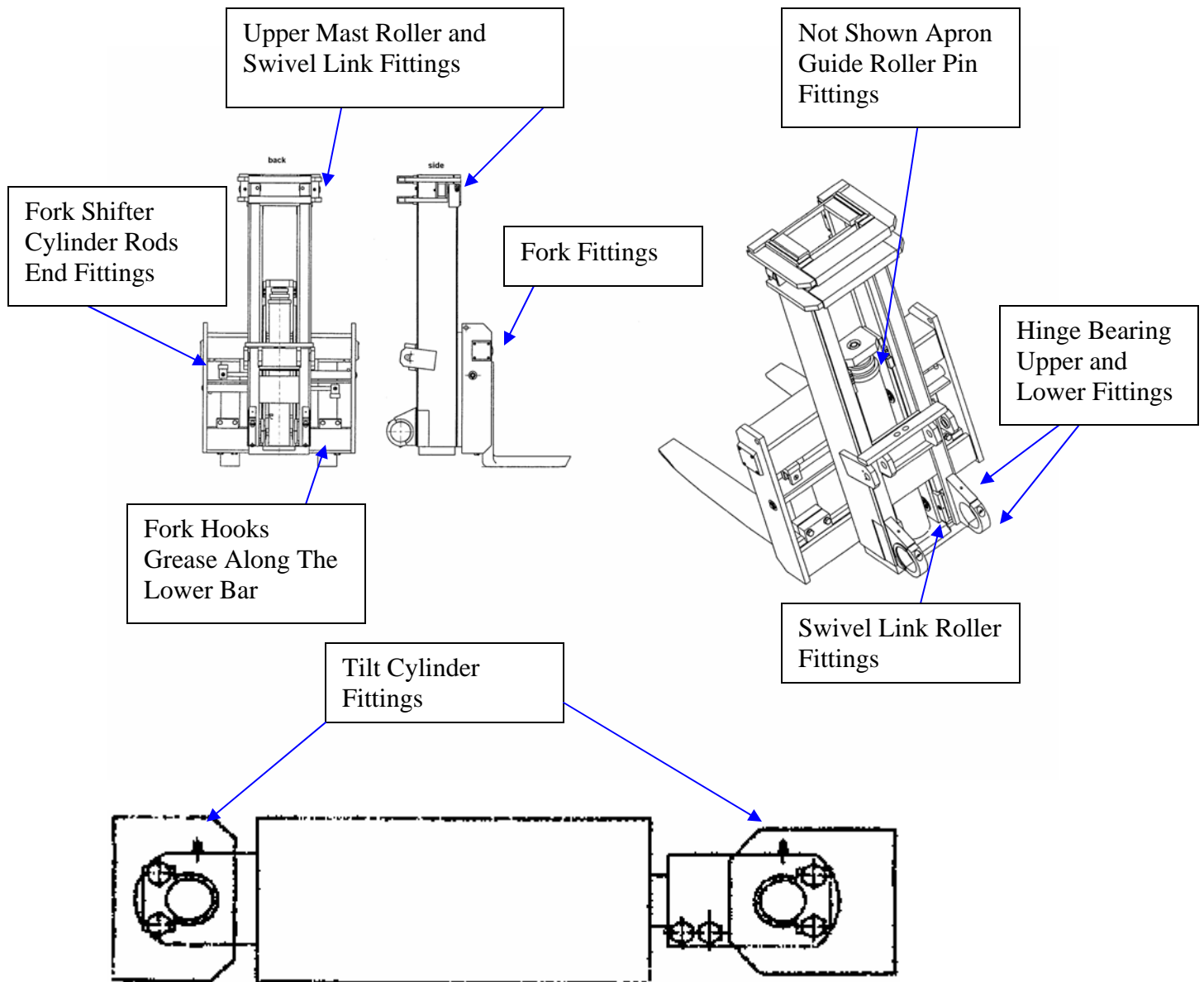
TYPE LITHOPLEX RT2 GREASE

STEER AXLE

TYPE LITHOPLEX RT2 GREASE

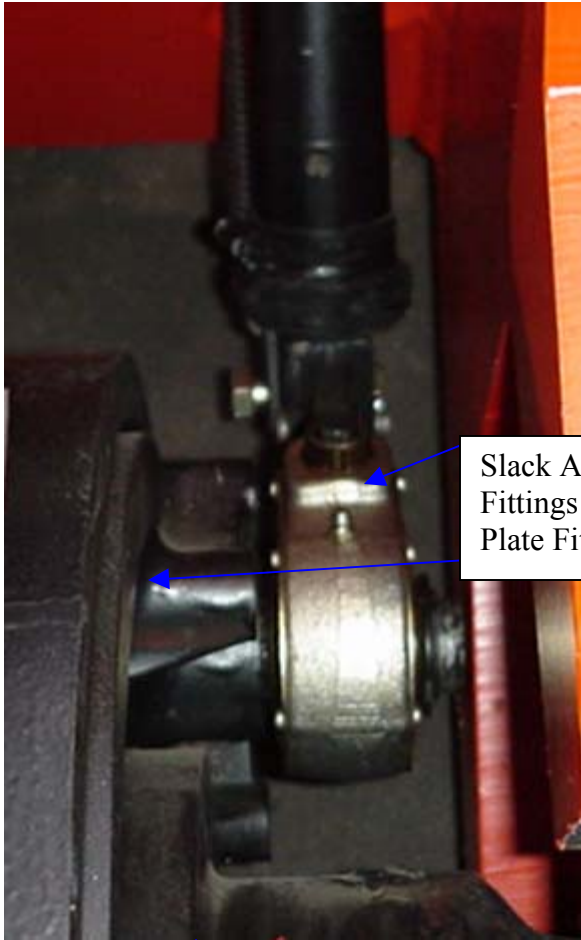
FKS MAST LUBE POINTS

It is recommended that the moving parts of the mast be lubed with a good quality grease "LITHOPLEX RT2" every 250hrs



FKS DRIVE AXLE LUBE POINTS

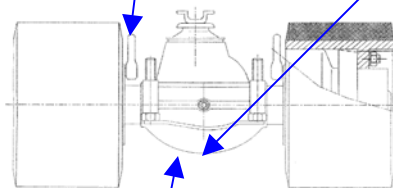
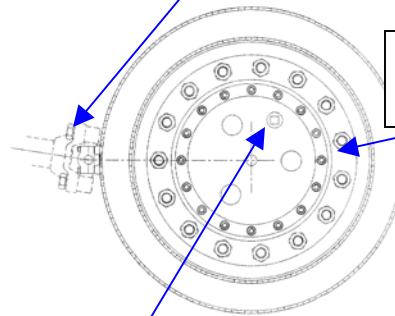
It is recommended that the moving parts of the drive axle be lubed with a good quality grease "LITHOPLEX RT2" every 250hrs



Slack Adjuster
Fittings and Backing
Plate Fittings

Drive Shaft U-Joint
Fittings Drive and
Motor Ends

Drive Axle
End

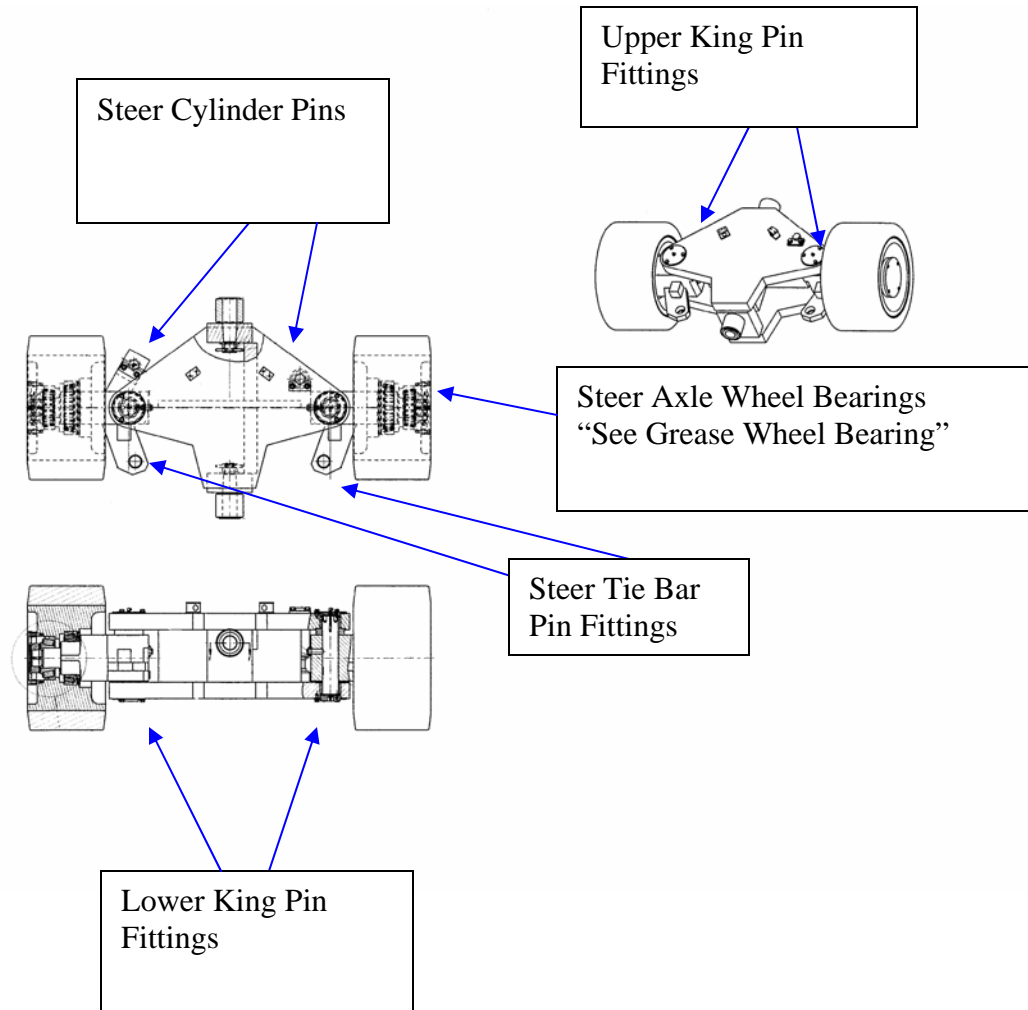


Center Section

Drive Axle Fill Plug/Drain Plug Location. To check the level of the oil the truck needs to be on a level surface. Rotate the drive axle till the axle drain/fill plug is level with the floor. Oil level is just even below the drain plug. To drain the from the axle end rotate 90 the axle till the drain plug is facing down. Not shown is the drain /fill/center plug of the center section. To drain center section remove the bottom plug. To fill remove the top plug and fill till oil is even with or just comes out of the center plug. Use 80W/90 Gear Lube.

FKS STEER AXLE LUBE POINTS

It is recommended that the moving parts of the steer axle be lubed with a good quality grease "LITHOPLEX RT2" every 250hrs



GREASING WHEEL BEARINGS

Procedures:

- A. Raise the seat frame.
- B. Disconnect the negative battery cable.
- C. Engage the parking brake.
- D. Raise the steer axle off the ground and support
- E. Remove steer wheels by pulling steer wheel cup. Remove cotter pin, slotted hex nut and wheel.
- F. Remove inner wheel bearing with proper bearing spreader, being careful not to damage the roller cage.
- G. Remove contaminated grease from bearings, wash bearings with solvent and dry bearings with air being careful not to spin the bearings.
- H. Examine bearings for pits, corrosion, or wear.
- I. Replace bearings if they are damaged.
- J. Pack bearings with Lithoplex RT2 grease or equivalent.
- K. Using a suitable Mandrel, Press the inner bearing onto the spindle.
- L. Slide wheel onto spindle and install the outer bearing, washer and nut.
- M. When tightening steer wheel nuts make sure to spin wheel while tightening nut. When correct preload is present back the slotted hex nut off to the first flat and secure with cotter pin. Clean wheel cap off and apply bead of silicone just under crown of cap and install cap, this will prevent water from entering wheel bearings.
- N. Take truck off of blocks. Reconnect negative battery cable. Close seat frame. Test drive to assure steering operates correctly.

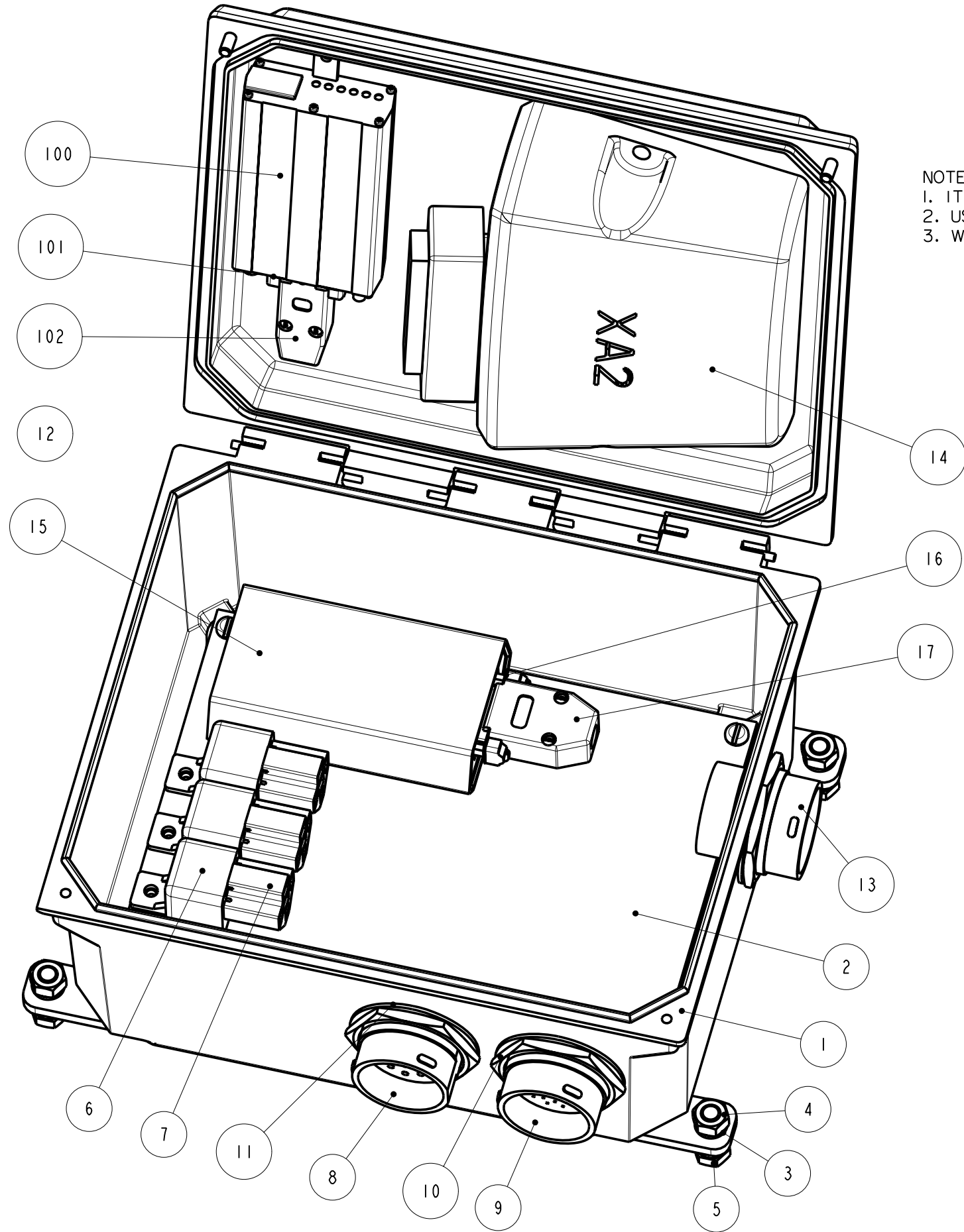
F Series IGNITION DELAY



IGNITION DELY
M06189 NOTE:
location of this part
may not be mounted as
shown.

NOTE: IT IS VERY IMPORTANT THAT IGNITION DELAY IS NOT BYPASSED FOR ANY REASON. DAMAGES TO THE ENGINE AND STARTER CAN RESULT.

The purpose of the ignition delay is to insure that the engine has started to rotate prior to the voltage being supplied to the ignition coil and spark plugs. This prevents a kickback that could occur if a small amount of fuel remains in one or more of the combustion chambers.



- NOTES:
- 1. ITEMS #100 AND OVER ARE FOR REFERENCE ONLY - SEE BOM IF CO3964 REMOTE TECH ASM REQUIRED
 - 2. USE DOUBLE SIDED TAPE TO MOUNT RESISTOR BOARD MI5734
 - 3. WIRING HARNESS W00001 NOT SHOWN ON DRAWING

REVISIONS			
REV	DESCRIPTION	DATE	CHANGED BY
A	CONNECTOR M11874 REPLACED BY M08841	1 Dec 08	MACIEK G.

102	M1335I-1	D-SUB CONNECTOR COVER	1
101	M1335I	D-SUB CONNECTOR 15 PIN MALE	1
100	M13305	CELLULAR MODEM	1
18	W00001	WIRING HARNESS FOR E00001	1
17	M15806-1	D-SUB CONNECTOR COVER	1
16	M15806	D-SUB CONNECTOR 15 PIN MALE	1
15	M15734	RESISTOR BOARD	1
14	M12866	IQAN I/O MODULE XA2	1
13	M11874	CONNECTOR 23-PIN FEMALE	1
12	M10778	CONNECTOR IQAN TOC8 CONTROLLER	1
11	M08844	LOCKWASHER	3
10	M08843	PANEL NUT	3
9	M08841	CONNECTOR, 31 PIN	1
8	M08839	CONNECTOR, 16 PIN	1
7	M04999	SOCKET	3
6	M03151	CHANGE OVER RELAY	3
5	F00551	M8x25 HHCS	4
4	F00244	M8 HEX NUT HIGH	4
3	F00230	8MM LOCK WASHER	4
2	B13272	PANEL, ELECTRICAL BOX	1
1	B13271	ELECTRICAL BOX LPG / DIESEL	1
ITEM	PART #	DESCRIPTION	QTY

ALL WELDING CONTINUOUS EXCEPT AS INDICATED.
ALL STRUCTURAL STEEL TO BE PAINTED WITH RED
OR GREY PRIMER UNLESS OTHERWISE SPECIFIED.

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Design and invention Are Reserved.

DIMENSIONS
ARE IN "mm"

X ±0.4
X.X ±0.1
Ang. ±0.5°

NAME
ELECTRIC BOX ASSEMBLY LPG/DIESEL

TECHNICAL INFORMATION:

DESIGNED BY: MACIEK G. WEIGHT (lbs/Kg) -

DRAWN BY: MACIEK G. SHEET 1 OF 1

FINISH NOTE: - QTY 1

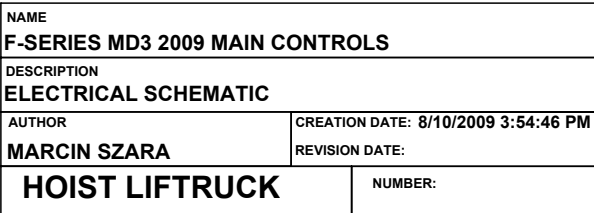
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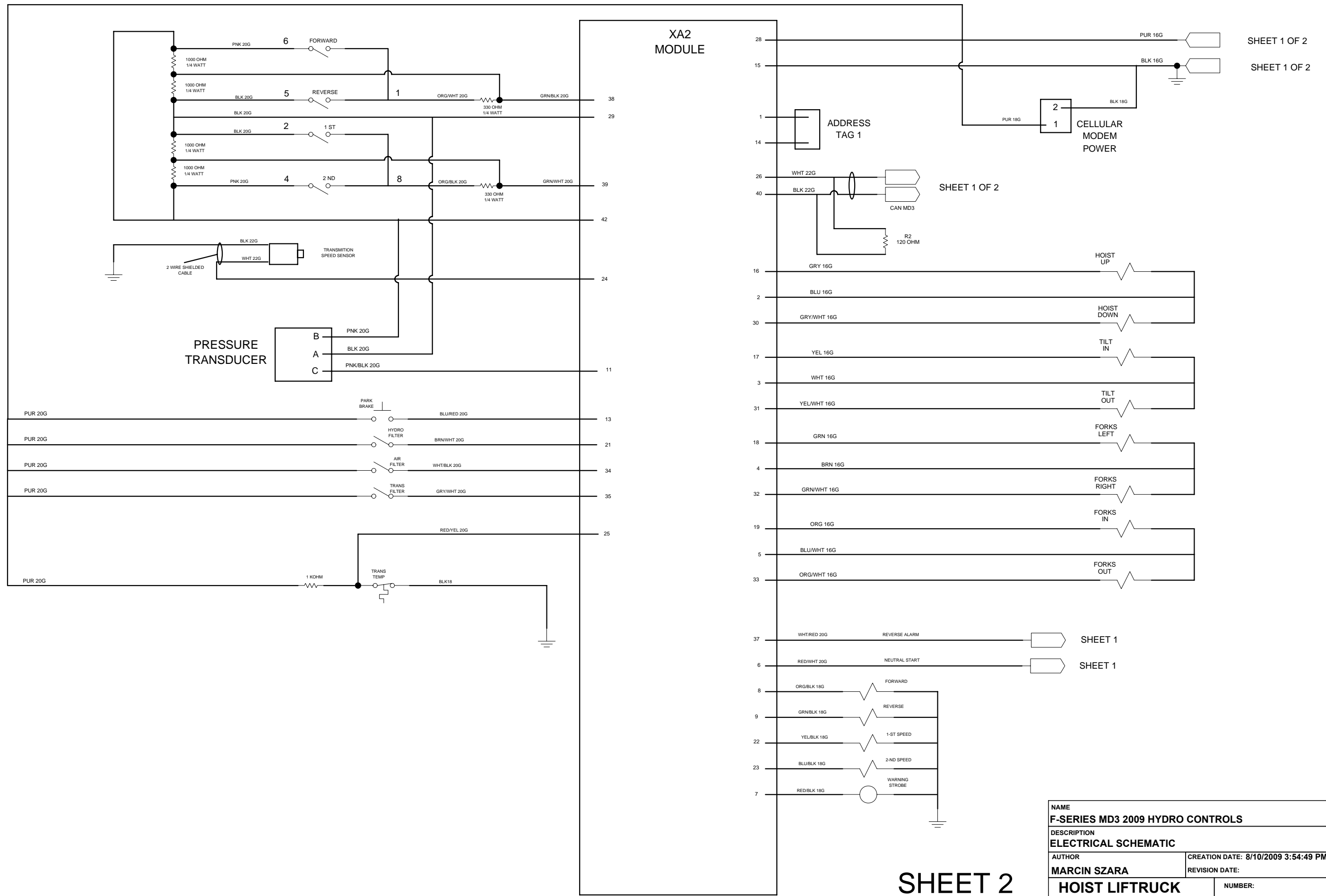
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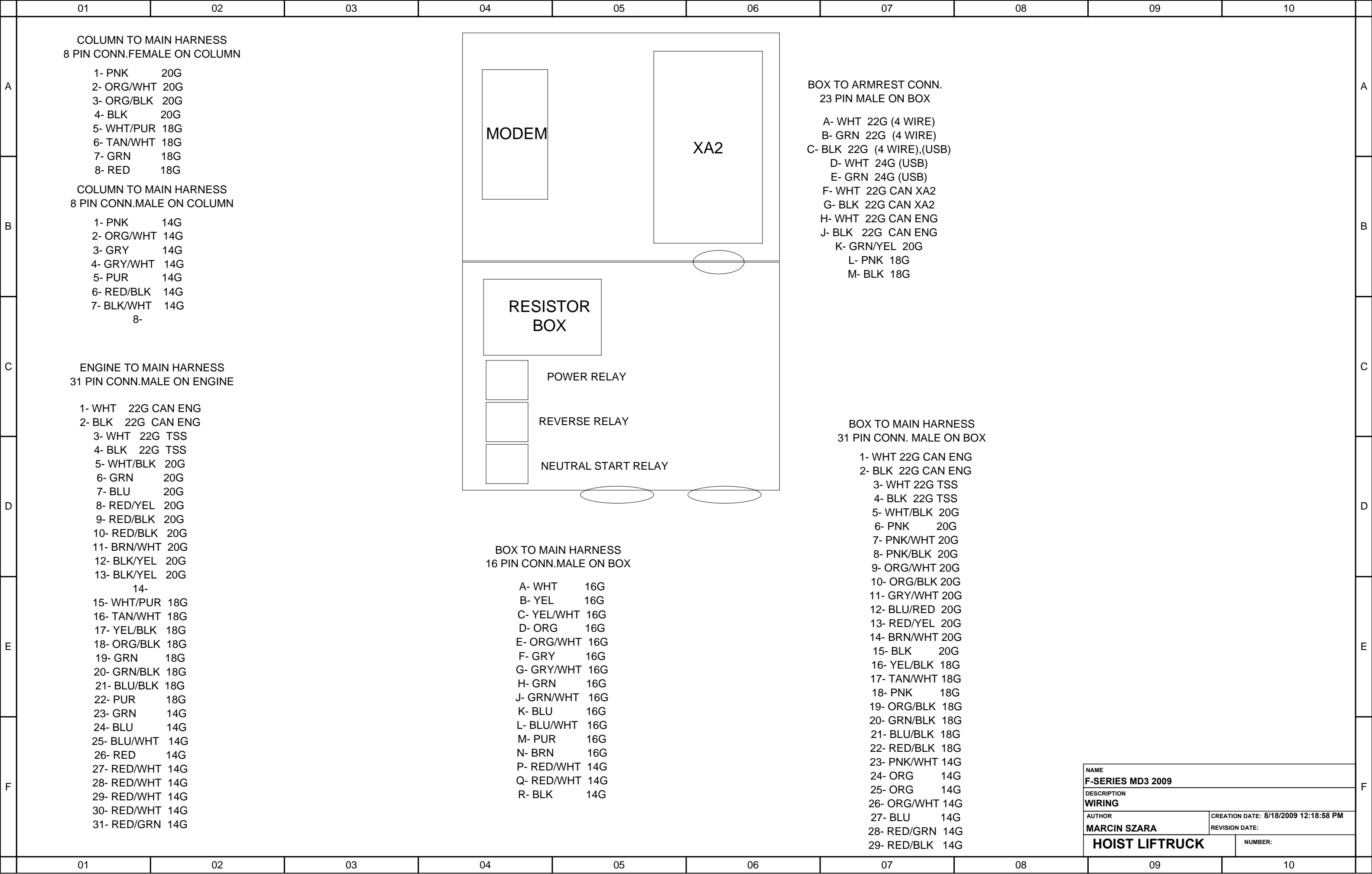
USE WITH MD3 DISPLAY

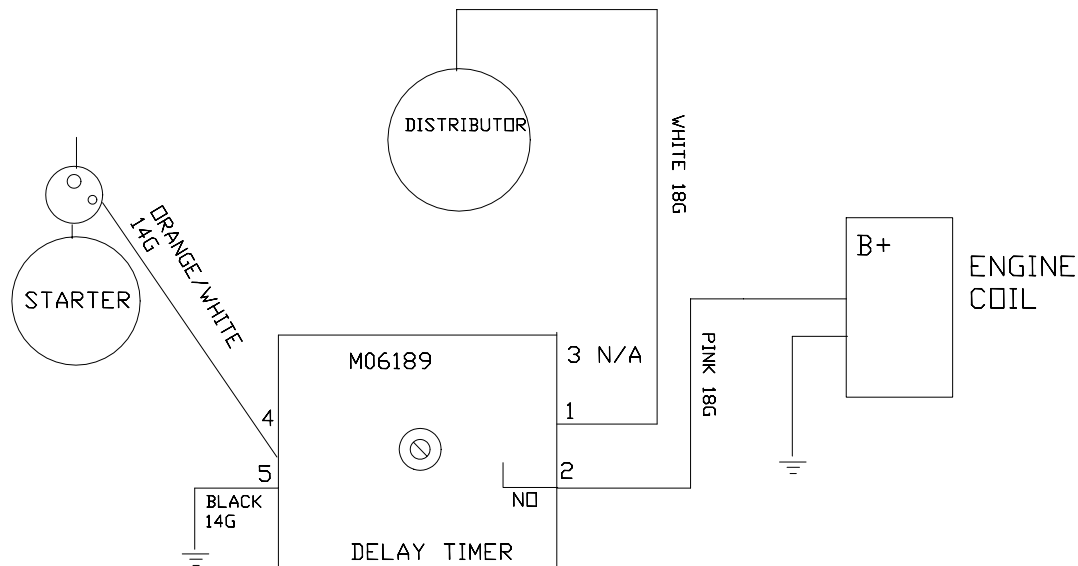
HOIST LIFTRUCK MFG., INC.
6499 WEST 65-TH STREET
BEDFORD PARK IL.60638

HOIST
LIFTRUCK

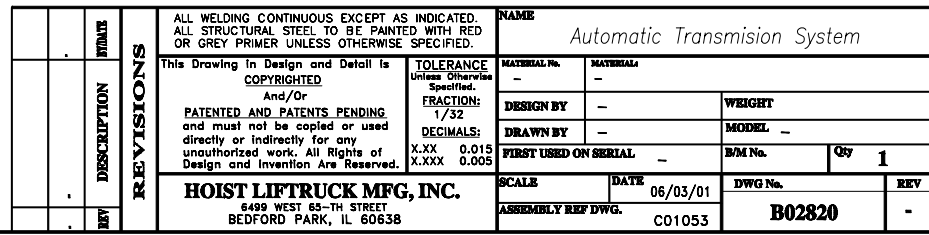


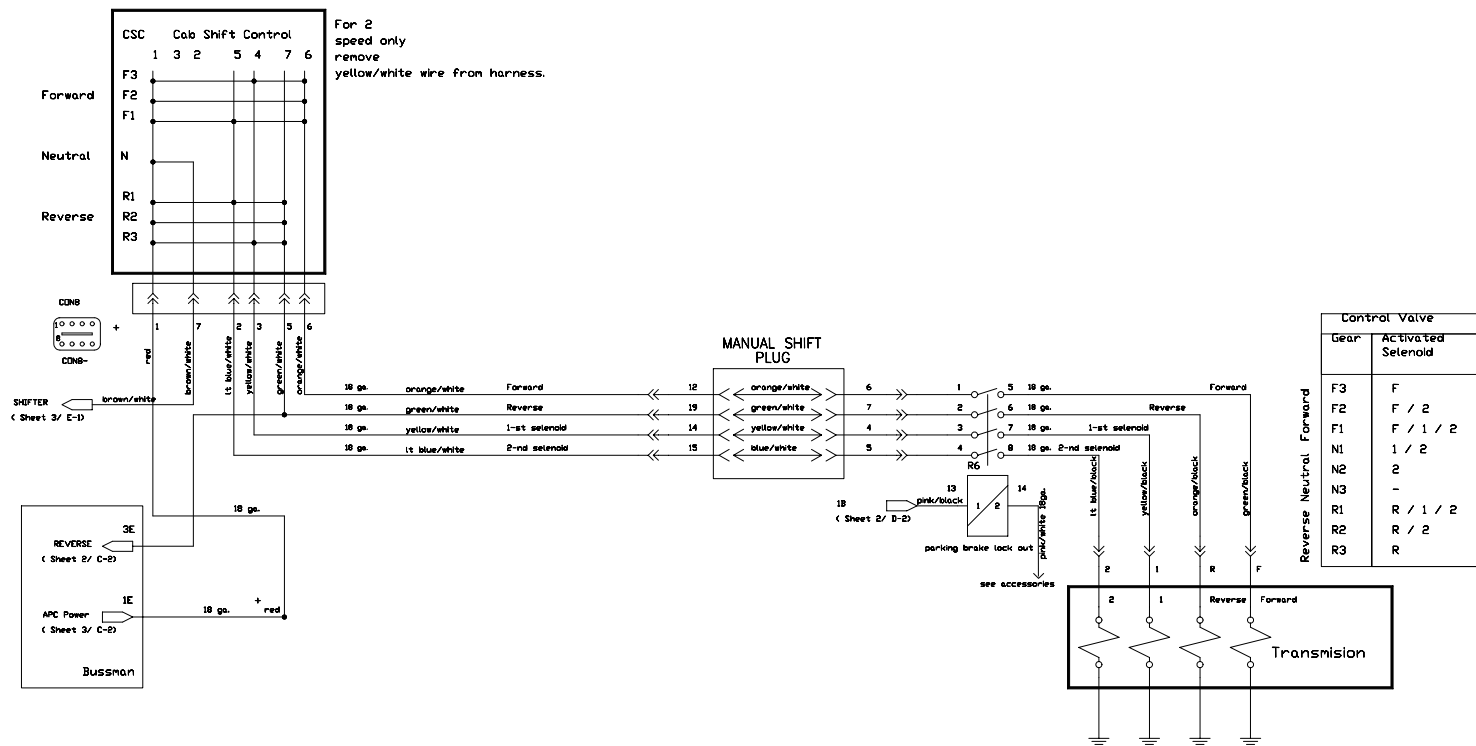






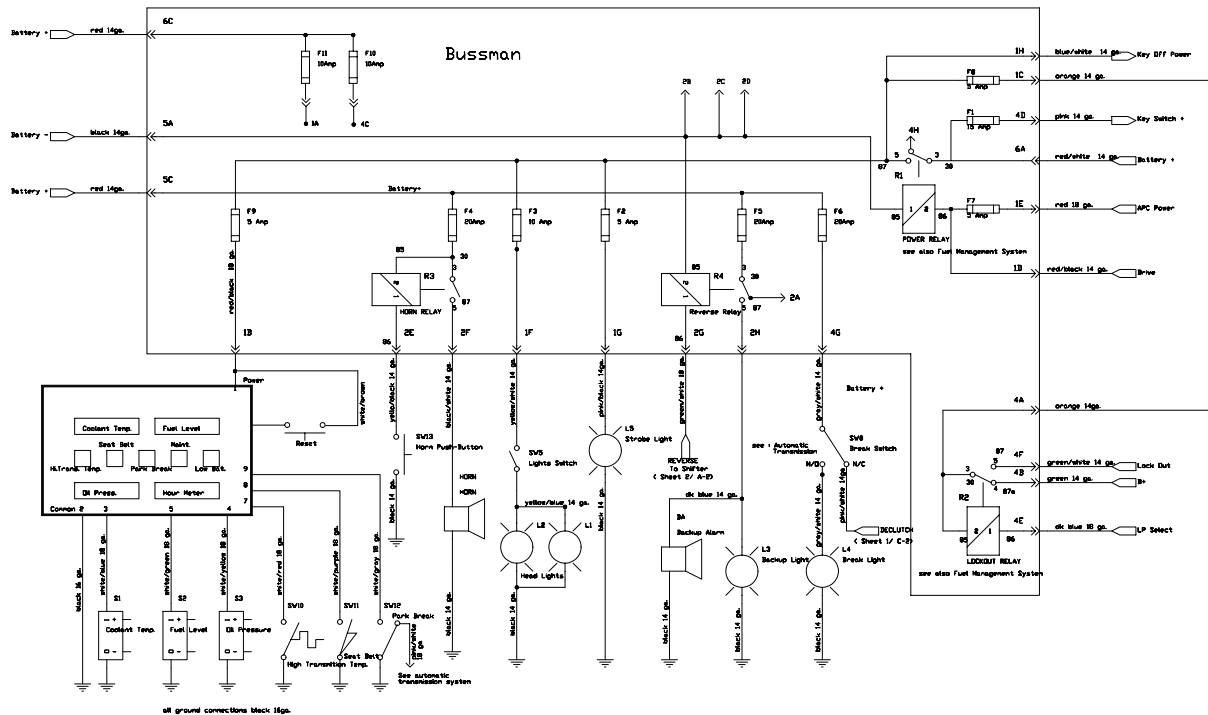
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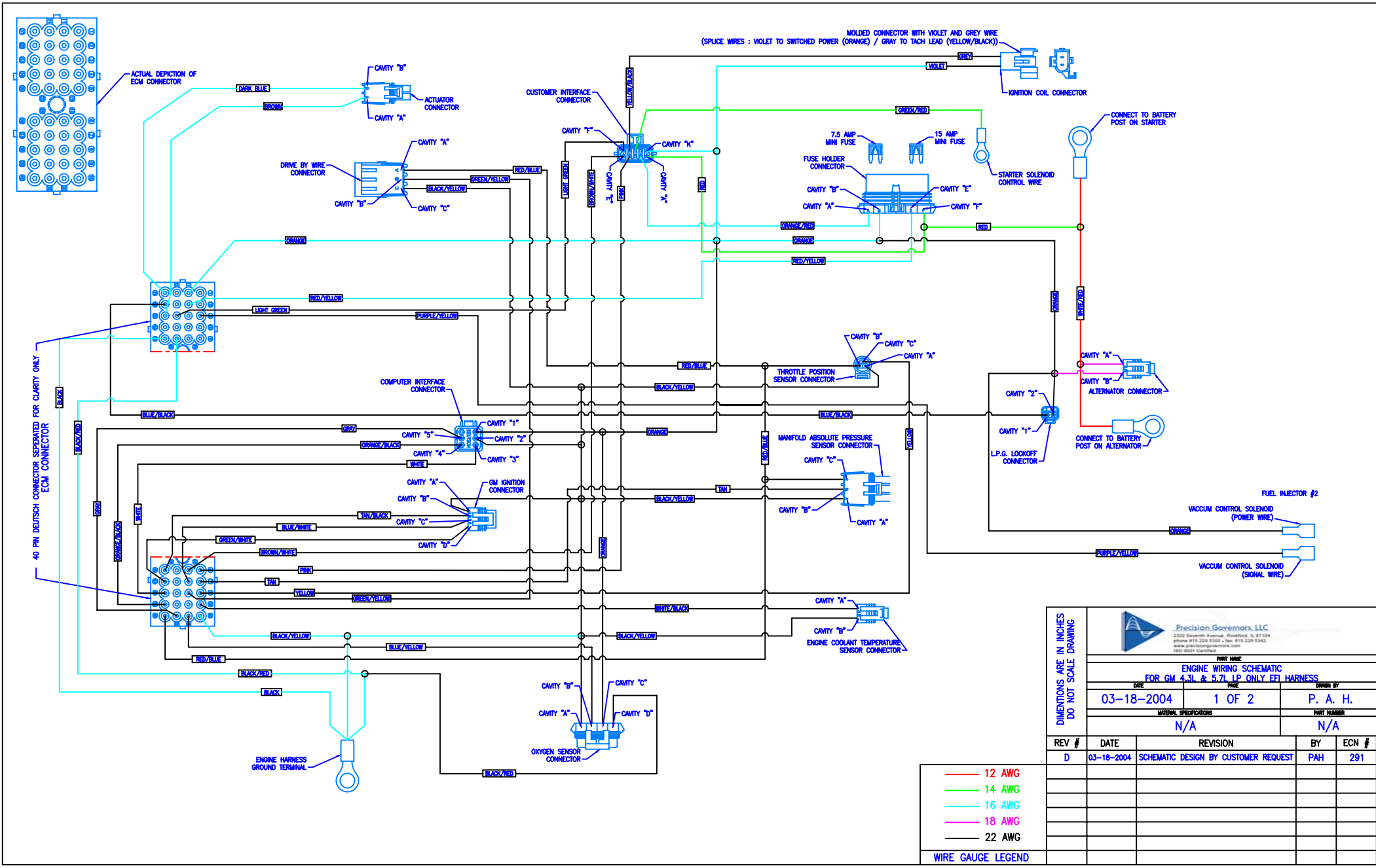
REV		DESCRIPTION	DATE

REVISIONS		ALL WELDING CONTINUOUS EXCEPT AS INDICATED. ALL STRUCTURAL STEEL TO BE PAINTED WITH RED OR GREY PRIMER UNLESS OTHERWISE SPECIFIED.	NAME Manual Transmission System
This Drawing In Design and Detail is COPYRIGHTED And/Or PATENTED AND PATENTS PENDING and must not be copied or used directly or indirectly for any unauthorized work. All Rights of Design and Invention Are Reserved.		TOLERANCE Unless Otherwise Specified, FRACTION: 1/32 DECIMALS: X.XX 0.015 X.XXX 0.005	MATERIAL No. - MATERIAL: - DESIGN BY - WEIGHT DRAWN BY - MODEL - FIRST USED ON SERIAL - B/M No. - QTY 1
HOIST LIFTRUCK MFG, INC. 6499 WEST 85-TH STREET BEDFORD PARK, IL 60638		SCALE - DATE 10/08/02 ASSEMBLY REF DWG. C01053	DWG No. B02820-2 REV -



1-BLACK
2-WHITE
4-GREEN

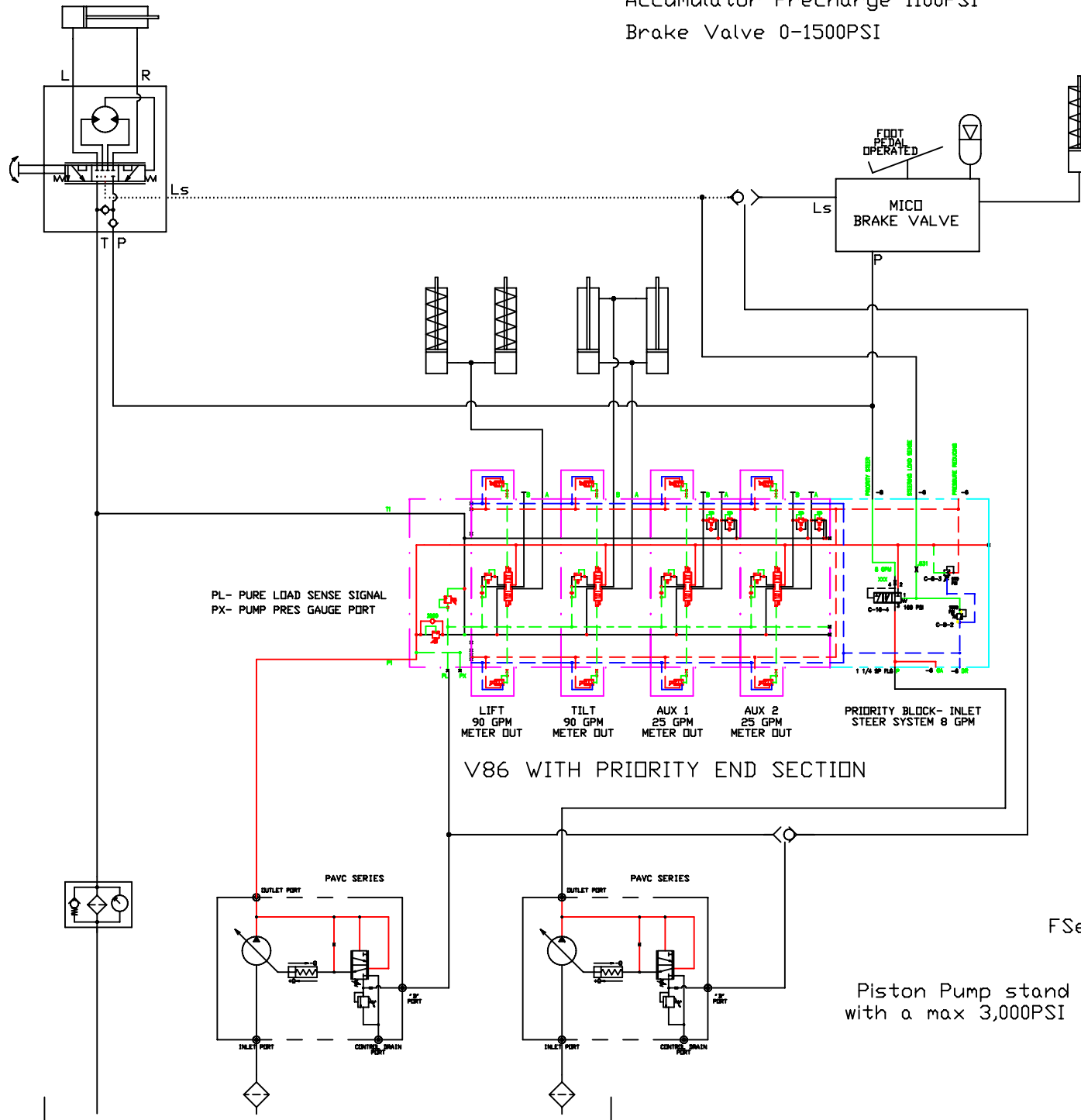
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STEERING CYLINDER

Accumulator Precharge 1100PSI

Brake Valve 0-1500PSI



F Series 500,600,800

Piston Pump stand by pressure 475 PSI
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